THREE ESSAYS ON HOUSING QUALITY IN THE UNITED STATES

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Housing quality matters both for the physical health and development of people who occupy it and for the safety and stability of neighborhoods where it is located. Urban planners have thus long been interested in the determinants of housing quality and ability of policy to influence the physical condition of housing stock. In this dissertation, I examine three questions related to the physical quality of housing in the United States. In my first essay, I study whether and through what channels deteriorating housing in Cleveland, OH impacts the neighborhoods in which it is located. In my second essay, I study whether regulations which constrain the development of new housing affect the prevalence of certain housing problems. Finally, in my last essay, I examine various ways in which families alter the quality of housing they consume in the face of high housing prices and limited supply. My research contributes to both our academic understanding of how housing markets function and provides insights for planners and policy makers as they develop policy to improve housing quality in their communities.

BIOGRAPHICAL SKETCH

Daniel Kuhlmann is Ph.D. Candidate in the Department of City and Regional Planning at Cornell University. In his research he draws on the fields of urban planning, urban economics, sociology, and housing studies to examine issues relevant to contemporary US housing policy. Kuhlmann received a M.A. in Urban and Regional Planning from Cornell and a B.A. in International Relations from Carleton College.

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CHAPTER 1

INTRODUCTION

Background

In this dissertation, I study issues related to the quality of housing in the United States. Housing quality describes both a house's structural characteristics and the physical condition of that structure. Structural characteristics are generally fixed when a developer first builds a house, but conditions can change over time based on the maintenance and investment decisions of property owners. An examination of housing quality must thus consider why developers build (or fail to build) the housing that they do and why owners have maintained (or failed to maintain) their structures over time. Housing quality can affect the people who occupy it and the blocks, neighborhoods, and cities which housing itself occupies. A poor-quality house can affect the physical and mental health of its occupants, just as it can the safety and stability of its neighborhood (Evans, 2003; Harkness & Newman, 2005; Ioannides, 2002).

In the past, scholars and policy makers have been most interested in quality in the context of substandard and deficient housing. Around the turn of the 20th century, for example, many people lived in houses which lacked basic amenities, such as indoor plumbing and safe heating equipment. Others lived in units that were unsafe due to overcrowding, poor ventilation, or insufficient maintenance (Riis, 1914; Von Hoffman, 1998).

Because of the prevalence of housing problems, there was arguably no greater policy concern for many local governments than improving the age, safety, and physical condition of the housing stock. Indeed, some of the first government interventions in private housing markets aimed at solving problems associated with low-quality and unsafe housing. Planners designed many of the early building codes, zoning laws, and direct or indirect housing subsidy programs that still exist today with explicit goal of improving the physical quality of both the units people occupy and of the larger housing stock (Lubove, 1963).

Because of these policy efforts, and a marked increase in household incomes, today most people occupy larger, safer, and better-appointed houses than did those living just fifty years prior (Gyourko & Tracy, 1999). For example, in 1985 approximately 12% of housing units in the US were, based on the department of Housing and Urban Development's (HUD) standards, either moderately or severely inadequate. By 2013, fewer than 5% were.[1] If we had similar data back earlier into the 20st century, this trend would likely appear in even starker contrast. These gains have led some policy analysts to dismiss, or at least downplay, the importance of housing quality as a research topic (e.g., Malpezzi & Green, 1996). But, as I will demonstrate in the essays that follow, even though people today on average occupy better quality housing than they did fifty years prior, we should not abandon either our academic or policy interest in issues related to the physical quality of the housing stock.

Housing quality remains a useful research topic for primarily two reasons. First, although housing standards have improved across the US, there are still thousands of people who occupy relatively poor-quality housing. While only 5% of national housing stock is inadequate, this represents over 5 million units.

[1] Based on the author's calculations using the 1985 and 2013 national waves of the American Housing Survey.

Understanding why housing quality problems persist and describing how they affect the people who occupy them and the neighborhoods and cities where they are located are worthy empirical projects.

Second, studying the characteristics of housing people consume can provide insight into how housing markets function. In most contemporary academic and policy work on private housing markets, analysts are primarily concerned with questions related to how market conditions impact housing costs. There is good reason for this. Housing costs are relatively easy to observe, and, in many cities, prices have risen dramatically over the last several decades. But focusing exclusively on housing costs misses other ways in which housing market problems may affect people. We should be concerned about how much consumers spend on housing, of course, but we should also be concerned with what they receive for these expenditures. Even in cities where quality problems are rare, examining differences in the quality of housing people consume is necessary to understand the housing problems that confront these places.

To this end, while each of the essays I present here orbit the larger topic of housing quality, I use the focus on quality to study larger housing market problems facing American cities. As Metcalf (2018) succinctly explains, we can classify cities in the US into three categories based on characteristics of their housing markets. In the first are a set of large, primarily coastal cities where demand for housing is high, but developers have been unable (due to a combination of regulations and geographic constraints) to build enough housing. Other cities, like those in the industrial northeast, face the opposite problem. In these cities, a declining population has led to oversupply of housing. Finally, in a third group population is increasing, but developers are building apace, thus expanding the housing supply.

The impact that these three types of market dynamics have on housing prices is clear. Academic and policy analysts have shown that in high-demand places that limit new supply, prices rise; in declining cities, prices fall; and in places where new development keeps pace with demand, prices moderate (Been, Gould, & O'regan, 2017; E. L. Glaeser & Gyourko, 2005; Gyourko, 2009). We focus less, both in policy and academic analyses, on the impact that these diverging trends have on the quality of cities' housing stocks.

The relationship between market conditions and housing quality is the most straight-forward in declining cities. When housing values fall below the price of new construction, developers find it difficult to turn a profit building new housing. And with low housing values, owners of existing property have less incentive to invest in maintenance. In places like Detroit and Cleveland, for example, few developers find it profitable to build new housing and problems of blight and abandonment are prevalent in many neighborhoods. Quality problems in declining cities, simply put, are an expected outcome of low levels of residential demand and low housing prices.

We should also expect that in cities where new housing construction keeps up with population growth, the quality of the housing stock will be high. Without major renovations, a house's quality is the best when it is new. As a house ages, even with steady investments in maintenance, a unit's overall quality will decline (if for no other reasons than its design or aesthetic appeal becomes outdated). Thus, in markets where new development is pervasive, housing quality is high simply because the housing stock is, on average, newer.

But it is difficult to predict how constraints on new development, coupled with high residential demand will affect the quality of the housing stock. On the one hand, in these places, because housing is expensive, we may expect a net increase in the quality of housing despite these places having an older housing stock. This could occur if people adapt to the limited supply of new housing by investing more in upgrading the existing stock. Certainly, at the neighborhood-level this does occur—urban commentators often use the upgrading of old housing as a bellwether of gentrification.

But on the other, even if the supply constraints lead some people to spend the money they would use to build a new house on renovating an existing structure, not all households are able to adapt in this way. Others, especially middle- and lower-income households, respond to high housing prices by changing their housing consumption in other ways. For example, people can respond by moving to neighborhoods, cities, or regions where housing is less expensive. And those who stay in place can change either the amount of money they spend on housing or by changing the type of housing they occupy. Some households may cope with high prices by crowding into relatively small housing while others may overlook certain housing problems.

Overview of Papers

In the three essays that follow, I examine issues of housing quality as they exist in two types of housing markets. In the first, I study an issue related to poor-quality housing in declining cities. Although we should expect population loss to lead to a decline in the average quality of a place's housing, the process through which this decline spatially manifests within these cities is more complex. Indeed, within declining cities, quality problems are much more pervasive in some neighborhoods than in others. Planners and policy makers are thus interested in understanding the spatial distribution, and proliferation, of quality issues even where the global cause of these problems is well-known.

In this project, I use data from a property conditions inventory conducted by the Cleveland non-profit the Thriving Communities Institute to examine whether housing units in poor physical condition negatively affect other properties in their neighborhood. I provide two tests in this essay. In the first, I use a combination of geospatial and econometric techniques to measure the impact that neighborhood property conditions have on residential sales value. In the second, I examine how nearby housing quality affects the likelihood that individual units will themselves be in poor physical condition.

My results suggest little association between proximity to housing units in the worst physical quality and sales values, once I control for a robust set of unit and neighborhood characteristics. I do, however, identify a relationship between sales values and proximity to housing units with moderate housing problems, especially in neighborhoods where housing problems are rare. In the second analysis, I identify a strong association between proximity to poor-quality housing and the likelihood that a unit itself has observed quality problems.

These results suggest that the quality of the housing stock plays a role in neighborhood decline. If lower housing prices cause owners to invest less in maintenance, and proximity to other poor-quality housing unit's lower neighborhood sales values, then even an isolated housing problem may, if unaddressed, lead to a decline in neighborhood-wide housing quality.

In my second and third essays, I turn my attention to housing quality in markets with high demand, but constraints on development limit new housing production. In both essays I use data from metropolitan waves of the American Housing Survey (AHS) to examine how living in expensive, supply-constrained places affects the quality of housing consumers occupy. Although the question motivating these two projects is similar, the way in which I approach it differs between the two. In the second I examine whether there is an association between regulations on new development and the prevalence of certain housing problems. While in my third, I examine whether living in supply-constrained places affects the type of housing people consume.

In my second essay, I combine the results of the AHS with a development regulation measure, the Wharton Residential Land Use Regulation Index (WRLURI). I use these data to estimate a series of models which predict the likelihood that a unit has one of several quality problems based on market-level constraints, and controls for unit, occupant, and market characteristics. Through this analysis I identify a surprising negative association between market-level regulatory restrictiveness and the likelihood that a unit has a cosmetic or structural problem. I discuss in this essay some possible explanations for this result, including challenges with measuring both development regulations and housing problems and the impact supply-constraints can have on the demographic composition and wealth of metropolitan areas.

Although in my final project I still test whether living in a supply-constrained housing market alters the quality of housing people consume, this essay differs from my second in two key ways. First, and most importantly, in this project instead of comparing differences in metro housing stocks based on their relative level of supply constraints, I examine differences in housing consumption based on whether people live in constrained- or unconstrained metros. Second, in this analysis I use a broader definition of housing quality, not just the presence or absence of certain quality problems. In this paper, in addition to several unit adequacy measures, I test the association between supply constraints and unit age, the presence of unit amenities, subjective measures of unit quality, and crowding.

The results I present in my final analysis differ from those in the second. In all my models I control for an extensive set of occupant socioeconomic variables, unit and neighborhood characteristics, as well as housing market fixed-effects. With these controls, I still identify an association between a family's location in an expensive, supply-constrained market and the likelihood that they occupy older houses, units lacking central air-conditioning or in-unit washer and dryers, and crowded housing.

This design also allows me to analyze how market-level supply constraints impacts the housing consumption of people at different income levels. Somewhat to my surprise, I find that most of the differences I observe between people living in constrained and un-constrained markets exist for middle- and high-income households. I identify little difference in the housing consumption of lower-income people based on the characteristics of the housing market in which they live. In the concluding section to this dissertation, I provide some commentary on why this may be.

Structure of this Project

In the pages that follow, I present each of my three essays in-turn. First is my examination of the impact that poor-quality housing has on neighborhood properties in Cleveland, OH. Next, I are my two essays examining how constraints on new housing development affect the quality of housing people in these places consume—first, my essay in which I study whether supply-constraints are associated with an increased prevalence of certain housing problems and second, the essay which I use a broader definition of housing quality to study differences in housing consumption. I end with a brief section describing challenges I encountered in this project and where research on housing quality should go next.

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CHAPTER 2

AN EXAMINATION OF THE SPILLOVERS PRODUCED BY HOUSING UNITS IN POOR PHYSICAL CONDITION

Introduction

Although much recent urban commentary focuses on how the back-to-the-city movement is driving up rents in hip urban neighborhoods, many central cities in the US continue to struggle with problems of low demand and shrinking populations (J. Hackworth, 2001; D. S. Hyra, 2017; Mallach, 2018; K. Newman & Wyly, 2006a). In declining places, a key question facing local policymakers is how best to cope with an aging and physically decaying housing stock. Despite the prevalence of these problems, our empirical understanding of the ways in which houses in poor physical condition harm neighborhoods is underdeveloped. Measuring the impact that housing disrepair has on neighborhoods is thus crucial to improving both our understanding of the dynamics of neighborhood housing markets and, importantly, our ability to craft policy that responds to these problems.

Over the last twenty years, policymakers in declining cities have struggled with the question of what to do with a growing stock of residential structures in disrepair. Although many places have programs to help homeowners maintain their properties, due to constrained local budgets and little state and federal funding, these preventative programs have been limited in their scope and, ultimately, impact (DBR Task Force, 2014). Instead, most cities only intervene when a property has reached a severe state of disrepair. Using a mix of local, state, and federal funding, governments around the country, but especially those in the post-industrial rustbelt, have launched large-scale programs to demolish nuisance properties.

The Cuyahoga County Landbank, for example, one of the of the earliest and largest of these programs in the country, demolished over 5,000 residential properties in the Cleveland area by the end of the first quarter of 2017. This policy focus on demolitions is born primarily, and understandably, of necessity—a large stock of severely decayed properties is a liability to cities like Cleveland. But, proponents of these programs also argue that these houses negatively impact neighborhood property values and that removing them will help stabilize neighborhood decline and bolster the local property tax base (Hackworth, 2016).

Examining the strength of this second claim is difficult. While there is a strong, negative relationship between neighborhood-level property distress and sales values, the causal nature of this relationship likely flows both ways. The presence of low-quality housing can lower sales values, but low sales values can also lower the quality of a neighborhood's housing stock. To further complicate matters, there are many other factors exogenous to neighborhoods themselves that can cause a decline in both sales values and housing quality. Crime, racial and economic stigma, and historic planning decisions can all depress neighborhood sales values, which in turn can decrease maintenance and increase the prevalence of housing problems.

In this paper, while I am unable to fully unpack the complicated relationship between neighborhood housing quality and housing prices, I provide two tests which suggest the presence of poor-conditioned housing does indeed affect neighborhood housing outcomes. To do this, I build a dataset on housing conditions and sales values in Cleveland, OH, combining property characteristics and sales information from the

Cuyahoga County assessor with detailed housing conditions data from a property conditions inventory conducted by the Cleveland-based non-profit the Thriving Communities Institute (TCI). I use these data to examine two ways in which poor-conditioned housing may affect nearby properties—by directly lowering sales values and by increasing the likelihood that a property itself is in disrepair.

In the first test, I find some evidence that proximity to physically distressed houses lowers sales values. I build hedonic price models predicting sales values based on proximity to poor-conditioned housing and a series of observed property characteristics and neighborhood fixed-effects. These models suggest, somewhat surprisingly, that there is little association between proximity to the worse quality housing and sales values. I do, however, find an association between moderately distressed properties and low housing prices, especially when I limit my data to sales in neighborhoods where the overall condition of the housing stock is quite high.

In the second test, I find evidence that at the block-level, the presence of poor-quality housing units contributes to spatial patterns of housing distress. While controlling for unit characteristics and census tract fixed-effects, my models suggest an association between the physical condition of an individual house and that of its neighbors. Across Cleveland, even when I control for census tract fixed-effects, a unit's proximity to other poor-quality houses increases the likelihood that the unit itself will be in poor condition.

I structure this essay as follows. In next section, I discuss the ways in which housing units in poor condition may impact neighboring properties. I then summarize the previous scholarship on this topic. Next, I describe the data and methodology I use in this analysis. I then explain the findings from my statistical analysis. Finally, I conclude with a discussion of the results and implications for local policy.

How might housing conditions transmit harm?

In this project, I am interested in understanding whether, and through what channels, poor-conditioned housing affects other properties in their neighborhood. In this way, my study contributes to research interested in understanding why the demographic, economic, physical, and social characteristics of neighborhoods (and by extension cities) change over time (Ellen & O'Regan, 2011; Quercia & Galster, 2000; Solomon & Vandell, 1982). While there is some agreement that an under-maintained housing stock is an outcome of neighborhood decline, we know less about how housing conditions contribute to this process (Rosenthal, 2008).

There are at least two ways in which properties in poor condition can affect their neighborhoods. First, and most directly, a dilapidated property can act as a disamenity that impacts how other households in the neighborhood enjoy their property. Just as a family may enjoy their home more when it has a pleasant view, they may enjoy it less when it looks out on a dilapidated house. Further, even if a neighbor is uninterested in aesthetics, they may dislike a nearby dilapidated property if they fear it will attract other nuisances. As scholars have studied in the neighborhood effects literature, people fear that a poor-quality house will attract crime, pests, or pose a fire or safety threat that can spill across property lines (Sampson, 2013; Sampson, Morenoff, & Gannon-Rowley, 2002).

Second, a poor-quality house may serve as a signal to neighborhood residents that the area is in decline. Even if a family cares little about the direct nuisance a dilapidated house poses, it may cause them to question the long-term stability of the neighborhood. This is especially true in neighborhoods with many owner-occupied houses, as families will be concerned about the quality of their neighborhood for both personal and financial reasons. Even if a nearby dilapidated house does not affect their own enjoyment of their home, they may worry that it will affect its value either now or in the future.

And even if their worries are ungrounded, this behavior can push a neighborhood into what Bradbury et. al. (1980) describe as a cycle of self-fulfilling expectations. Demand for housing is based, in part, on the condition of nearby properties and property owners base their maintenance decisions on their perceptions of current and future demand for their unit. If a property falls into disrepair, it may serve as a signal to owners of a decline in the demand for housing in their neighborhood. In response, they may invest less in maintenance on their unit, thus lowering the condition of their property. If this happens, when the owner sells their unit, the neighborhood-wide decline in property conditions confirms their fears of a decline in housing demand.

As way of example, consider a residential neighborhood in which all the housing units are in roughly the same physical condition. One day, one of the residents passes away and her house is stuck in prolonged estate battle following her death. As her family sorts the estate, no one maintains her property and the unit begins to show external signs of disrepair, such as peeling paint, sagging gutters, or an overgrown lawn.

This change may impact neighboring properties in one of two ways—by lowering neighborhood property values and by lowering housing conditions across the neighborhood. First, if the owner of a nearby unit decides to sell, a buyer may pay less for their unit given the disrepair of its neighbor. The new buyer may view the unit in poor condition as a disamenity impacting their enjoyment of their house, a sign that neighborhood property values are in decline, or both. I a poor-quality unit lowers neighborhood housing values, it will also impact the investment decisions of owners in the neighborhood. If they believe the decaying unit will impact the value their home, or if it lowers their enjoyment of their property, they may be less willing to invest in routine maintenance. With less maintenance, these neighboring properties will also begin to show signs of disrepair.

Ultimately, regardless of the channel through which a poor-quality house transmits harm, in neighborhoods where it does the result will be the same—lower housing prices and a general decline in the condition of housing across the neighborhood. This is important to understand both when designing policy to address these problems and, as I will discuss more in the next section, when designing empirical studies to study these dynamics.

Neighborhood Characteristics and Housing Prices

A house's value is determined not only by the intrinsic characteristics of the unit (its quality), but also by the characteristics of the neighborhood and city in which it is located (the value of the land on which it sits). The overall price of a house is thus an aggregation of the individual prices of its physical characteristics, such as the number of bedrooms, construction quality, age, and the price of various locational attributes, such as distance to major employment centers, neighborhood amenities, school quality, and neighborhood safety. However, although each individual characteristic of a house contributes to its overall price, because we buy (or rent) houses as a bundle it is impossible to observe the individual price of each unit and neighborhood feature. Just as it is impossible to pick and choose the exact combination of features we want in a house.

Understanding the impact that individual unit and locational characteristics have on housing values, however, has both policy and practical value. Homeowners, for example, want to know how renovating their kitchen or bathroom will impact the value of their home. And when policy makers are considering building a new piece of infrastructure, they want to know how this development will impact nearby housing values and, by extension, property tax revenues. Given the relevance of these questions, there is a deep literature in which analysts seek to estimate the individual value of the various components of the housing bundle.

Researchers working in this area use one of two empirical methods—cross-sectional hedonics or paired-difference repeat sales models. Repeat sales studies use longitudinal data on property sales, matching units that have sold multiple times over a given period and measuring the change in prices between sales. They identify price changes based on variation in unit and neighborhood characteristics during the inter-sales period. This design requires not only longitudinal data on property sales, but also variation in the unit or neighborhood characteristic of interest. Because of this, the repeat sales design is most effective for studying discrete changes to neighborhood characteristics, such as the extension of a transit line or exposure to residential foreclosures. Scheutz et. al (2008) for example, use the repeat sales method to estimate the price effects of exposure to residential foreclosures in New York City.

In this study, while I have access to time-series data on property transactions, given the cost associated with a property conditions inventory, I only have cross-sectional data on housing conditions. Further, even if longitudinal property conditions data were available, it would be difficult to convincingly isolate the effect of changes in property conditions from other changes in neighborhood characteristics. In instances where longitudinal data are unavailable, or where changes manifest slowly, studies have instead used hedonic models to estimate price effects. This method, first introduced by Rosen (1974), use cross-sectional data and a large number of controls to identify the impact on property values of various components of the housing bundle.

Scholars have used versions of this design to estimate the price of a wide range of unit and neighborhood characteristics, including: transit access (Al-Mosaind, Dueker, & Strathman, 1993; Bartholomew & Ewing, 2011), low-income and public housing (Baum-Snow & Marion, 2009), crime (Gibbons & Machin, 2008; Kuminoff, Parmeter, & Pope, 2010), and pollution (Anselin & Lozano-Gracia, 2009; Smith & Huang, 1993). Hedonic price models are probably the most common research designs used to quantify the effect of spatial exposure to various neighborhood characteristics.

There is to my knowledge only one previous empirical study in which researchers control for proximity to houses showing external signs of disrepair in their hedonic specification. In one of the earliest published hedonic housing studies, Kain and Quigley (1970) test the impact that residential quality has on the sales price and rents of housing units. They use data from a survey which asked several questions on the condition of nearby housing units, such as whether neighboring structures were of better or worse quality than the subject property and whether the respondent considered any buildings in the neighborhood nuisances. The authors use factor analysis to create a single measure of the quality of proximate properties based on eight survey questions. In their models, Kain and Quigley find that the physical condition of the sold unit has a large and statistically significant impact on both sales prices and rents but find little statistical association between neighborhood housing conditions and prices. They do not, however, dedicate much space to exploring this result.

And since Kain and Quigley's early study, few scholars have studied the impact the physical condition of neighborhood properties have on housing prices. It is only very recently that scholars have begun to focus again on the neighborhood spillovers that housing units in poor physical condition may transmit. Following the surge in mortgage defaults during the housing crisis, several studies have modeled how foreclosed residential units impact nearby property values.

A foreclosure could influence nearby property values in two ways. First, because foreclosures often sell at a discount they may drag property values down by lowering the average assessment in the neighborhood. Second, foreclosed homes usually sit vacant for some period as banks work through the legal process. During this time, they may attract crime which may present as a disamenity for those considering purchasing in the neighborhood. Or, especially if left vacant for a long period, foreclosed properties may begin to physically decay if banks or investors fail to protect the property from vandalism or invest in routine maintenance.

Researchers estimate that each additional nearby foreclosure lowers sales values, holding observable unit and neighborhood characteristics constant, by between one and ten percent (Anenberg & Kung, 2014; Campbell, Giglio, & Pathak, 2009; Gerardi, Rosenblatt, Willen, & Yao, 2012; Harding, Rosenblatt, & Yao, 2009; Hartley, 2014; Immergluck & Smith, 2006; Leonard & Murdoch, 2009; Lin, Rosenblatt, & Yao, 2007; W. H. Rogers, 2010; W. Rogers & Winter, 2009). In general, these scholars find that the price effect of exposure to foreclosure attenuates quickly with distance—that is, the nearest foreclosures have the largest impact on sales value. While previous scholarship consistently identifies an association between lower sales values and proximity to foreclosures, there is less agreement on how exactly foreclosures transmit harm.

To my knowledge, there is no empirical research that examines specifically the price-effect of foreclosure-related declines in property conditions. Several studies have indirectly measured the impact of property neglect by focusing their estimations on the effect foreclosure-related vacancies have on neighborhood sales values (Hartley, 2014; Whitaker & Fitzpatrick IV, 2013). But due to a lack of data on actual property conditions, they must assume vacancies lead to a decline in physical property conditions, rather than testing the impact of physical neglect directly. Although in my present undertaking I do not test specifically the impact that foreclose-related abandonment and disrepair have on neighborhoods, my research can inform this larger scholarship by testing one of the hypothesized pathways through which foreclosures produce negative neighborhood spillovers.

In all hedonic research, scholars are interested in understanding the endogenous impact of some housing attribute on the houses price. The reflection problem, a term coined by the applied-economist Manski (1993), plagues this type of research, as it does much quantitative research on social issues. This problem arises when researchers attempt to infer attributes of an individual from their membership in a group. In the case of spatial hedonic models, we are interested in understanding how spatial proximity to some phenomenon (or, put differently, a unit's membership in a group of houses) affects the value of the unit. While this proximity may matter, the value of the observation may also influence the physical condition of nearby properties. To stick with the optics metaphor, housing prices may reflect the quality of the neighborhood housing stock, but the quality of the housing stock may also reflect prevailing area housing prices. Ultimately, I am unable to solve this reflection problem in my study, and thus I must consider it when interpreting my results.

In summary, outside of Kain and Quigley's early study, few researchers have examined how the physical condition of a neighborhood's housing stock impacts property values. And no scholarship, to my knowledge, empirically tests for a cycle of mutual disinvestment in which residents in neighborhoods in which physical disrepair exists respond by investing less in the maintenance on their own properties. While urban researchers have long theorized that property conditions play a role in cycles neighborhood decline and renewal (Bradbury, Downs, & Small, 1982; Brueckner & Rosenthal, 2009; Rosenthal, 2008), there has been little research into exactly how this dynamic plays out at the neighborhood level. Although some scholars find that housing characteristics influence tenure decisions and rates of neighborhood attrition, none to my knowledge have studied the impact that changes to the housing stock have on investment decisions (Immergluck, 2015). In this article, I provide a more direct test of this question by estimating two sets of regressions. In the first, I estimate with OLS models the association between exposure to poor-conditioned housing units and sales prices. In the second, I use logit regression to test the association between exposure to poor-conditioned units and the likelihood that a unit itself shows external signs of physical disrepair.

This Study

Based on previous research, I expect that exposure to poor-quality housing will negatively affect nearby properties. I expect this to manifest in two ways. First, based on the previous price effect literature, and especially that which examines the impact of exposure to residential foreclosures, I predict that housing located near units in poor physical condition will sell at a discount. I expect this effect to attenuate quickly with distance and the intensity of exposure. Second, I predict that housing conditions will also affect the maintenance decisions of nearby residents. I expect that holding other unit and neighborhood characteristics constant, proximity to poor-conditioned housing will increase the likelihood of a unit being in disrepair.

To test these hypotheses, I estimate two models using property-level data from Cleveland, OH. In the first, my outcome variable is the price of properties that sold in the city between 2010 and 2015. I control for a series of unit characteristics and hold neighborhood variation constant at the census tract. My primary explanatory variables in this model are a series of measures of each observation's exposure to homes exhibiting external signs of disrepair. The controls in my second model mostly match to those in my first. In the second specification, however, the outcome variable is a dichotomous measure of whether the observation itself exhibits signs of disrepair. In the remainder of this section, I discuss the data I use in this analysis. I then turn to a discussion of results.

Data and Methodology

My primary data source for this analysis is a property conditions inventory conducted by the Cleveland-based nonprofit, TCI. In the summer of 2015, TCI hired and trained a team of surveyors to perform external inspections on each of the approximately 158,000 parcels in the city. Over three months, the surveyors walked through each neighborhood with an internet-connected tablet, recording data based on a series of questions on the external physical condition of each unit. The surveyors recorded whether each building had peeling paint, damage to its roof, porch, gutters, sidewalk or chimney, boarded windows, garbage dumped on its lawn, and whether it was vacant, for rent or sale, or unsecured and open to the street. For each property, the surveyors also assigned a letter grade (A to F) (see **Appendix 1** for the grading guide provided to the surveyors). Although TCI captured data on every parcel in the city, I limit my sample to resident housing units with 3 or fewer units and, for certain controls, empty residentially-zoned parcels.

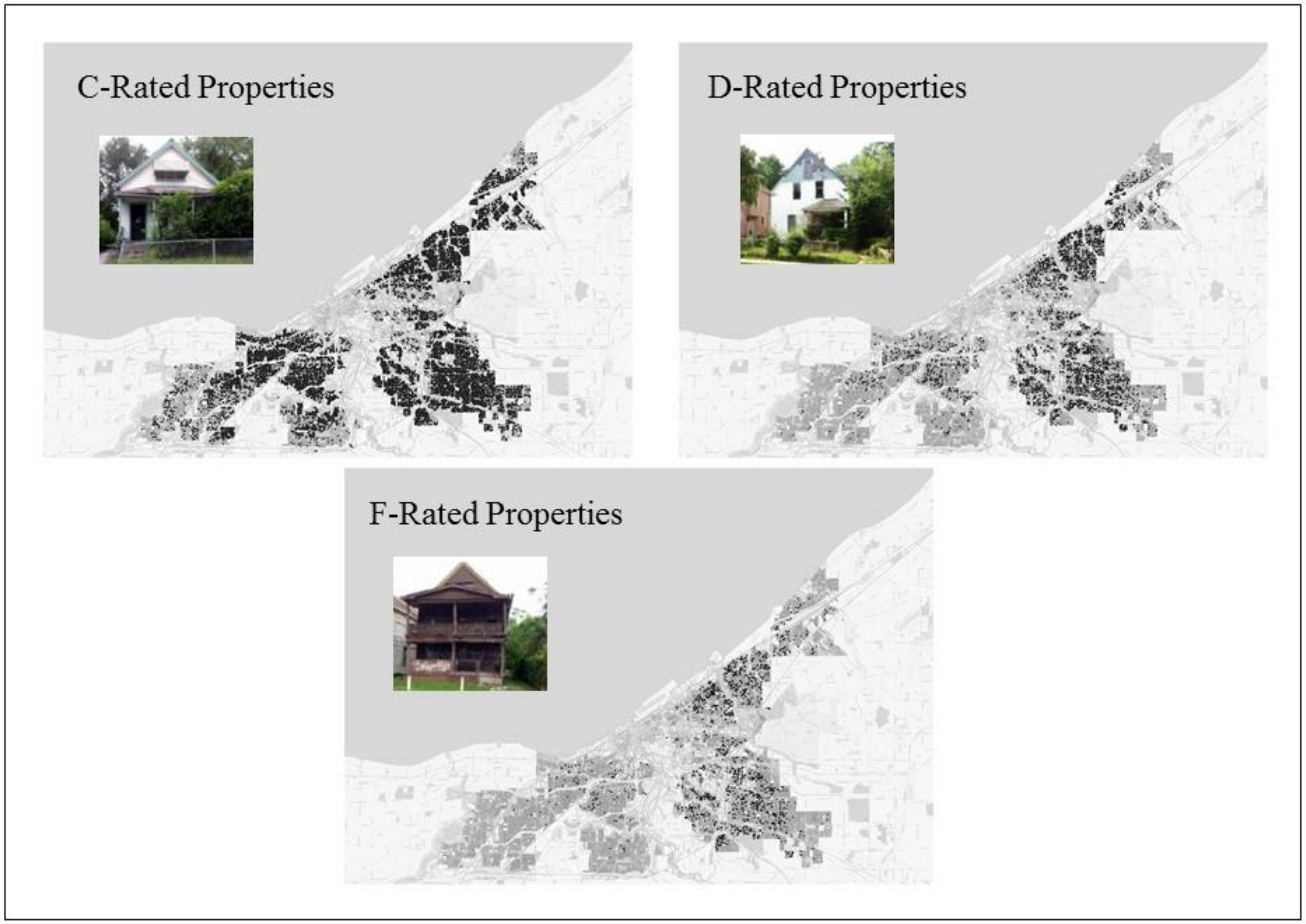
Table 1: *Condition Grades and Housing Problems*

	N	Vacant	Unsecured Vacancy	Roof Damage	Boarded Windows	Porch Damage	Paint Damage	Damage	Dumping	Sidewalk Damage
A	44,538	1%	0%	1%	0%	2%	3%	1%	0%	48%
B	45,594	4%	0%	15%	2%	22%	44%	11%	2%	49%
C	17,730	20%	2%	44%	13%	55%	81%	50%	7%	52%
D	3,902	63%	11%	66%	5%	79%	93%	80%	24%	57%
F	1,537	93%	29%	78%	81%	88%	94%	89%	44%	55%
No Grade	18,219	0%	0%	0%	0%	0%	0%	0%	7%	67%

Table 1 reports the results of the survey, broken out by housing grade and **Map 1** shows the spatial distribution of the C-, D-, and F-rated properties. Although there are relatively few D- and F-rated units in the city (3,902 and 1,537, respectively) these units have the significantly higher rates of physical disrepair than do those with one of the three other grades. Although the D- and F-rated units show the most

external signs of deterioration, in some specifications I also examine the effect of residential exposure to C-rated properties. Although in percentage terms C properties have fewer physical problems than those rated either D or F, given the relatively few D and F properties in the city, many of the units in the city showing signs of disrepair are those rated C. For example, although only 22% of C-rated properties have boarded up windows, this represents over 2,300 homes in the city, more than the approximately 1,400 such units among the D and F properties.

Map 1: *Quality Problems in Cleveland*



Measuring Proximity

Hedonic regression models, like those which I develop in this study, estimate the net impact of spatial proximity to some amenity (or, in the case of poor conditioned housing, nuisance) on housing values. This design requires not only a robust set of controls for unit and neighborhood characteristics, but also a method to measure proximity to the nuisance or amenity of interest. Previous scholarship uses primarily one of three methods to measure spatial proximity—neighbor, straight-line radii, or block face measures. The most common method used in the neighborhood effects literature, especially in studies that estimate the price effect of foreclosures, is the straight-line radius measure. Using GIS software, researchers draw buffers around each observation and count the cases of the phenomena of interest that fall within a given radius (see Immergluck & Smith, [2006]). This design is relatively easy to implement, but it assumes that the phenomena of interest communicates its harm or benefit purely through spatial proximity. That is, it assumes away that possibility that some other geographic or social boundary is also affecting the transmission of the price effect under study. For example, foreclosure studies using a straight-line radius measure gives proximate foreclosures the same weight regardless of whether they are located on the same street as the subject property. A property next door counts the same as one two blocks over, provided the latter still falls within the study's specified distance band.

Most previous scholarship that uses straight-line radius measures partially controls for this by including multiple distance bands (e.g. separate variables which count observations that fall within 0' to 250', 250' to 500', etc.) instead of one radius.

This design allows researchers to estimate different coefficients based on how far the amenity or nuisance falls from the observation. While this controls for the possibility that a hypothesized price effect may attenuate with distance, it does not directly control for the other networks which may affect a price effect's communication.

In other studies, however, scholars use different proximity measures that attempt to directly control for the other channels through which price-effects may produce harm. Those employing these designs argue that it is not just spatial proximity that generates neighborhood, but also direct interaction between the observation and the phenomena of interest. In the simplest version of these measures, researchers measure whether an observation directly neighbors a spillover-producing unit (Whitaker & Fitzpatrick IV, 2013). Other researchers use less constrained designs and measure proximity by colocation of the nuisance or amenity and the observation on same residential block. These so-called block face measures count the number of phenomena on the same street segment (usually defined as both sides of a street between two intersections) as each observation (Ellen, Lacoe, & Sharygin, 2013).

Map 2: *Measuring Proximity*

Most previous research in the housing price effects literature measures exposure to a specified amenity or nuisance using count variables. Researchers using this design assume that the magnitude of exposure matters. The size of a price effect will vary based on the intensity of an observation's exposure to amenities or nuisances. Some scholars, however, have questioned this assumption. Especially with nuisances, it is possible that exposure to a nuisance matters, but intensity of that exposure does not (or, at least, it may have a diminishing impact on property values). For example, the first foreclosure in a neighborhood may have large impact on the price of surrounding units, while each subsequent foreclosure may have a smaller effect (Schuetz et al., 2008). If this is the case, a dichotomous variable measuring whether there are any nearby instances of an amenity or nuisance may more accurately estimate the price effect of this exposure than would a count measure.

Theory about the way in which a local nuisance or amenity transmits its spillover should ultimately inform the decision of how to measure proximity most accurately. Houses showing external signs of disrepair may create spillovers that affect both its immediate neighbors and units in its wider neighborhood. People living on the same block as a property in disrepair may view it as direct disamenity that lowers their enjoyment of the neighborhood and, by extension, their house. But, if housing prices are based on the condition of the neighborhood and a potential buyer is aware of poor-conditioned units on the next block, units in disrepair may impact property values even if they are not directly observable from the sold unit. Further, it may also be the case that the first instance of residential disrepair has a large impact on property values, but the marginal impact of exposure to additional units quickly diminishes.

For these reasons, I test four measures of proximity in this paper. First, using GIS, I draw straight-line radii around each observation and I count the number of C-, D-, and F-rated properties that fall within 250', between 250' and 500', and between 500' and 1,000' (see panel 2 of **Map 2**). I also use a version of the block face measure to test direct exposure to poor conditioned housing. Measuring exposure on the block face, however, is not especially well-suited for Cleveland's urban form. Block face measures work best when used in a city with uniform street grid, like New York. While there are some neighborhoods in Cleveland with uniform block lengths, there is significant variation across the city. I thus create a new measure which I call a synthetic block which combines characteristics of the straight-line radius and block face measures. Again, I create buffers of 250', 250' to 500', and 500' to 1,000' around each observation. But, with the synthetic block measure, I only count C-, D-, and F-rated properties if they are located on the same street as the observation (see panel 1 of **Map 2**).

In an alternate set of specifications, I test the price effect of spatial exposure using dichotomous measures rather than counts. I repeat both procedures, but instead of counting the number of poor-conditioned units, I create a dichotomous measure given the value of "1" if there are any C-, D-, or F-rated properties that fall within the corresponding distance band and "0" if not. Finally, I use the counts from the synthetic block radii to create percentage exposure measures. In these models, the proximity variables are the ratio C-, D-, or F-rated properties to the total number residential properties within the three distance bands.

Table 2: Variables and Descriptive Statistics

Variables and Descriptive Statistics

Variable	Mean/N (1)		Variable	Mean/N (1)	
	Sales	All Units		Sales	All Units
# Vacant Parcels wn 250'	0.6	0.6	# D and F units wn 250' radius	1.08	--
# Vacant Parcels btwn 250' & 500'	1.5	1.5	# D and F units btwen 250' and 500' radius	2.67	--
# Vacant Parcels btwn 500' & 1,000'	2.2	2.2	# D and F units btwen 500' and 1,000' radius	9.10	--
Unit listed in Rental Registry?	3,013	11,200	# D and F units wn 250' synthetic block (SB)	0.24	0.23
Total Unit Area (000s SF)	1.5	1.5	# D and F units btwen 250' and 500' SB	0.37	0.37
Lot Area (000s SF)	5.2	5.4	# D and F units btwen 500' and 1,000' SB	0.56	0.57
# of Bathrooms	1.4	1.4	# C, D, and F units wn 250' radius	4.89	--
# of Bedrooms	3.3	3.4	# C, D, and F units btwen 250' and 500' radius	12.20	--
Unit's roof is hip-style?	903	6,754	# C, D, and F units btwen 500' and 1,000' radius	41.16	--
Unit's roof is gabel-style?	16,108	101,366	# C, D, and F units wn 250' SB	2.18	2.11
Unit has slate roof?	1,531	10,442	# C, D, and F units btwen 250' and 500' SB	2.48	2.44
Unit has shingle roof?	15,533	98,085	# C, D, and F units btwen 500' and 1,000' SB	3.28	3.24
One unit in structure?	13,087	83,605	# C units wn 250' radius	--	1.88
Rach-style design?	1,540	10,748	# C units btwen 250' and 500' radius	--	2.07
Colonial-style design?	10,423	66,182	# C units btwen 500' and 1,000' radius	--	2.60
Cape Cod-style design?	4,288	26,699	# D units wn 250' radius	--	0.18
Unit has a garage?	12,170	85,188	# D units btwen 250' and 500' radius	--	0.29
Unit has central air-conditioning?	2,337	13,802	# D units btwen 500' and 1,000' radius	--	0.45
Unit has brick exterior?	1,756	11,426	# F units wn 250' radius	--	0.05
Unit age?	89	88	# F units btwen 250' and 500' radius	--	0.08
Unit sold Sept to Dec.?	5,095	--	# F units btwen 500' and 1,000' radius	--	0.13
Unit sold May to Aug?	6,622	--	Is there a C, D, or F unit wn 250' (SB)?	9,630	--
Unit sold Jan to May?	5,635	--	Is there a C, D, or F unit btwn 250' and 500' (SB)?	10,739	--
Unit is rated C in TCI survey?	2,868	--	Is there a C, D, or F unit btwn 500' and 1,000' (SB)?	10,512	--
Unit is rated D in TCI survey?	652	--			
Unit is rated F in TCI survey?	253	--			
Unit less than 20 years old?	--	3,960			
Unit between 20 and 50 years old?	--	2,602			
Unit between 50 and 70 years old?	--	19,232			
Unit over 70 years old?	--	87,112			

(1) If the variable is a count measure, means are reported; for categorical variables, number of observations matching that category are reported.

Other Data

All other data in this study are from the North-East Ohio Community and Neighborhood Data for Community Organizing (NEOCANDO) database. NEOCANDO is a consortium of local governments, non-profit organizations, and academic partners across the Cleveland metropolitan area that collectively contribute information and funding to maintain this dataset of community indicators. In

Table 2, I provide a complete list of the variables I employ in this analysis. For the sales price model, I use data on single-family property sales from 2010-2015. I clean these data for non-arms-length transactions (these are primarily properties sold to investors buying in bulk) and properties that have sold multiple times during this five-year period. For the latter, I keep information on only the most recent sale. I only have property condition data from 2015, but I use sales data for years previous based on the assumption that property conditions are relatively slow to change and thus able to approximate earlier neighborhood housing characteristics. For all specifications where observations are sales, I also run models limiting my sample to only sales that occurred in 2015 as a check. Doing so has little effect on my results. In total, my dataset includes 17,352 unique, arms-length residential transactions (see **Table 3** for a breakdown of sales-by-year).

In my second model where I test the likelihood a unit is in poor physical condition, I have significantly more observations, since I include all residential structures with three or fewer units, not just the subset of these which sold over my study period. Thus, these models include between 74,244 and 109,937 observations depending on the specification.

I control for a series of unit characteristics, including: whether the unit has a brick exterior, central air conditioning, a garage, whether the structure has only unit, its architectural style, age, type of roof construction, number of bedrooms and bathrooms, total size, and series of dichotomous variables measuring the TCI condition grade of the observation. In addition to the proximity to poor-conditioned units, in all specifications I also include measures of proximity to vacant residential lots. To control for unit-tenure, I create a dummy variable measuring whether the City of Cleveland's rental registry contains a record for the unit. A city ordinance requires that all landlords register their units regardless of the structure size. It is possible that owners of smaller units are less likely to register, but this measure gives me a rough idea of whether the unit is renter- or owner-occupied. In the models where my observations are sales, I also include the year and the three-month period in which the sale occurred.

Table 3: *Sales by Year*

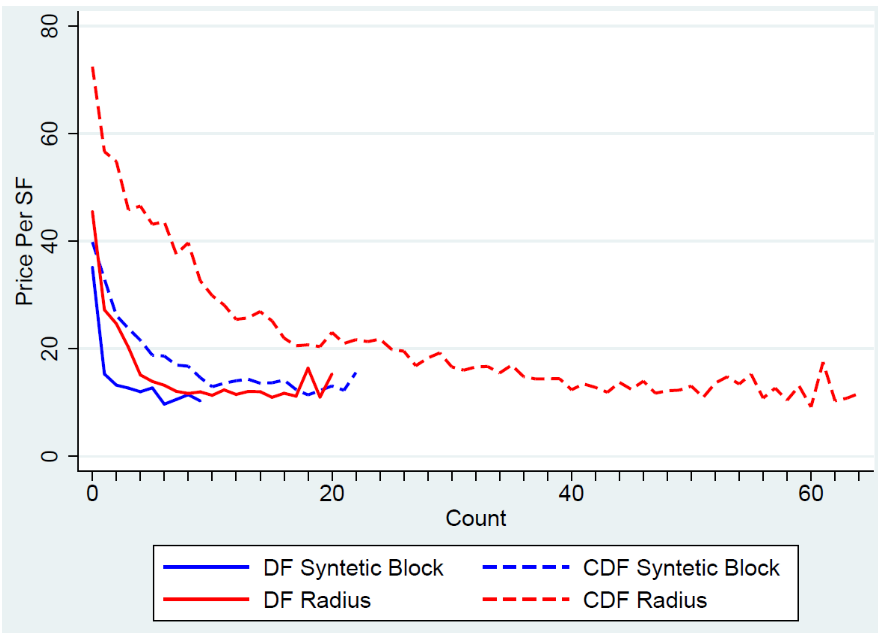
	Sales
2015	3,531
2014	4,005
2013	3,290
2012	2,464
2011	2,058
2010	2,004

Do housing conditions directly affect housing prices?

Figure 1 shows the basic association between the number of units in poor condition within 500' of a residential transaction and the average price per square foot (PSF) of those sales. There appears to be a strong negative association between exposure to poor conditioned housing units and sales prices. For example, properties with no D- or F-rated units within 500’ on their synthetic block sold, on average, for approximately $35 PSF. If a sale has just one D- or F-rated property in this radius, however, the average sales price drops by almost $20 to $15 PSF.

A similar relationship holds when I use straight-line radius measures instead of synthetic blocks and when I include C-rated properties. In all cases the marginal impact of poor conditioned units on sales values appears to decrease as exposure increases. That is, the first D- or F-rated property within 500’ appears to have a large impact on sales values, while each subsequent distressed unit has less of an impact. This makes intuitive sense if buyers are highly sensitive to the presence of any housing units in poor physical condition. If this is true, the first instance of a proximate unit in disrepair may absorb all the price effect of any subsequent exposure to such units.

Figure 1: *Average Sales Values by Exposure*



While this simple association indicates a potential relationship between exposure to poor condition housing and lower sales values, it could just as easily be picking up the influence of other unobserved neighborhood or unit characteristics that correlate with both housing conditions and prices. Thus, I next estimate a series of hedonic regression models testing the impact of proximity to houses showing external signs of disrepair on sales values, while controlling for other neighborhood and unit characteristics. **Table 4** presents the results of these regressions.[2] I logarithmically transform the dependent variable, the reported sales value, to create a normal distribution. The coefficients in these regressions thus represent a percent, rather than unit, change in the outcome variable. In all specifications, I include census tract fixed-effects (based on 2010 boundaries) and dummy controls for the year and quarter in which the sale occurred.

In the first two models, the primary independent variables of interest are measures of exposure to units rated either D or F in the TCI inventory. In Model 1, I measure proximity with a straight-line radius measure; in Model 2, I measure proximity on the more restrictive synthetic block. The results of these regressions fit with the simple relationship shown in Figure 2. In these specifications, each additional D or F unit within 250' of an observation is predicted to lower its sales price by around 4%. In both models, there is no statistically significant relationship between the number D and F properties within 250' and 500' and the observations sales price. In Model 1, however, having one additional D- or F-rated unit in the 500' to 1,000'

[2] In **Table 6** I list only the coefficients of the exposure variables. I report the full regression results in **Appendix 3**.

band is associated with a reduction of a property's price by approximately .6%. It is odd that exposure within the 500-1,000' band has a significant impact on sales values, but that within the 250-500' band does not. This result may because there are relatively few D and F properties in the city, and those that do exist are clustered in certain neighborhoods. While I control for census tract fixed effects, this largest radius group may be picking up clustering that occurs across census tracts. I discuss the spatial clustering of property conditions in more detail below.

In the first two models, while I control for a series of unit characteristics—such as size, age, etc.—I do not include controls for the physical condition of the sold unit. One should expect that the condition of a house will have a substantial impact on its sales price. Thus, in Models 3 and 4, I re-estimate Models 1 and 2 including three dichotomous variables measuring whether TCI surveyors rated the sold unit C, D, or F. There are two things to note with the addition of these variables. First, the coefficients of the three measures of whether the sold unit shows external signs of disrepair are highly statistically and economically significant—an important finding that I consider more in the second half of my analysis. Second, with the addition of condition controls, the coefficients on the proximity measures are no longer statistically different from 0 (except for the 500-1,000' band in Model 3).

Table 4: *Regression Results All Neighborhoods*

	Dependent Variable: LN(Sales Value)								
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
# D/F wn 250' (Radius)	**-0.038***** (0.007)	--	-0.002 (0.007)	--	--	--	--	--	--
# D/F btwn 250' & 500' (Radius)	-0.004 (0.004)	--	-0.007 (0.004)	--	--	--	--	--	--
# D/F btwn 500' & 1,000' (Radius)	**-0.006***** (0.002)	--	**-0.005***** (0.002)	--	--	--	--	--	--
# D/F wn 250' (Synthetic Block)	--	**-0.044***** (0.013)	--	0.022 (0.013)	--	--	--	--	--
# D/F btwn 250' & 500' (SB)	--	-0.019 (0.011)	--	-0.015 (0.010)	--	--	--	--	--
# D/F btwn 500' & 1,000' (SB)	--	-0.003 (0.008)	--	-0.004 (0.008)	--	--	--	--	--
# C/D/F wn 250' (Radius)	--	--	--	--	0.004 (0.003)	--	--	--	--
# C/D/F btwn 250' & 500' (Radius)	--	--	--	--	-0.002 (0.001)	--	--	--	--
# C/D/F btwn 500' & 1,000' (Radius)	--	--	--	--	**-0.002***** (0.001)	--	--	--	--
# C/D/F wn 250' (SB)	--	--	--	--	--	0.002 (0.004)	--	--	--
# C/D/F btwn 250' & 500' (SB)	--	--	--	--	--	-0.002 (0.004)	--	--	--
# C/D/F btwn 500' & 1,000' (SB)	--	--	--	--	--	-0.003 (0.003)	--	--	--
Percent of Houses C/D/F wn 250' (SB)?	--	--	--	--	--	--	-0.001 (0.001)	--	--
Percent of Houses C/D/F btwn 250' & 500' (SB)?	--	--	--	--	--	--	-0.001 (0.001)	--	--
Percent of Houses C/D/F btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	-0.001 (0.001)	--	--
Any C/D/F wn 250' (SB)?	--	--	--	--	--	--	--	**-0.104***** (0.023)	--
Any C/D/F btwn 250' & 500' (SB)?	--	--	--	--	--	--	--	-0.009 (0.023)	--
Any C/D/F btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	--	-0.037 (0.022)	--
Any C wn 250' (SB)?	--	--	--	--	--	--	--	--	**-0.104***** (0.022)
Any C btwn 250' & 500' (SB)?	--	--	--	--	--	--	--	--	-0.015 (0.023)
Any C btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	--	--	-0.031 (0.022)
Unit Rated C?	--	--	**-0.367***** (0.023)	**-0.371***** (0.023)	**-0.370***** (0.024)	**-0.371***** (0.024)	**-0.350***** (0.024)	**-0.346***** (0.024)	**-0.346***** (0.024)
Unit Rated D	--	--	**-0.710***** (0.045)	**-0.734***** (0.045)	**-0.723***** (0.044)	**-0.722***** (0.044)	**-0.694***** (0.045)	**-0.700***** (0.044)	**-0.703***** (0.044)
Unit Rated F?	--	--	**-1.265***** (0.068)	**-1.280***** (0.068)	**-1.276***** (0.068)	**-1.276***** (0.068)	**-1.245***** (0.069)	**-1.258***** (0.068)	**-1.259***** (0.068)
Census tract fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of sale fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter of Year Sale Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	17,352	17,352	17,352	17,352	17,352	17,352	17,352	17,352	17,352
Adjusted R-sq	0.386	0.384	0.409	0.408	0.409	0.408	0.408	0.409	0.409
ll	-25393.080	-25414.238	-25065.291	-25073.677	-25060.790	-25075.021	-25070.612	-25058.997	-25034.550
aic	51200.161	51242.475	50550.582	50567.354	50541.581	50570.042	50561.225	50537.994	50489.100
bic	52806.784	52849.098	52180.489	52197.261	52171.488	52199.949	52191.132	52167.902	52118.789

One possible explanation for this surprising result is that I am not measuring the impact of exposure to poor conditioned units correctly. As I mention, D and F houses are relatively rare and highly spatially clustered. C-rated units, however, are more common and located in a wider variety of neighborhoods. If there is a price effect associated with property conditions, it may be due to exposure to C units that exhibit modest signs of disrepair. To test this, in Models 5 and 6 I include C-rated properties in the exposure measures. In Model 5, I use the straight-line radius measure and find again that neither of the coefficients on the two nearest proximity bands are significant, while that on the band measuring exposure between 500' and 1,000' is negative and statistically significant. In the synthetic block model, none of the exposure coefficients are significant. Again, in both models the coefficients on the unit condition variables are large and statistically significant.

In my final two regressions, I follow Schuetz et. al. (2008), and measure exposure to physically distressed units using as a dichotomous measure instead of counts. As **Figure 1** suggests, perhaps buyers are highly sensitive to the first instance of physical disrepair, but once buying in a distressed neighborhood are less price sensitive to each additional unit in poor condition. In Model 7, I operationalize exposure using dichotomous variables measuring whether each observation has any C-, D-, or F-rated units within the three distance bands along the synthetic block. In this model, a sale exposed to unit in disrepair within 250' is associated with a 10% decline in the unit's sales price. This effect is due primarily to exposure to C-rated houses. In Model 8, I replicate Model 7, using instead a dichotomous measure of whether there is a C-rated property within the three distance bands. In this alternative specification, the coefficients on my proximity measures are nearly identical to those in Model 7.

In all models, exposure to vacant parcels is consistently associated with lower sales values. Depending on the specification, each additional vacant parcel within 250' is associated with between a 2.6% and 3.5% decline in a unit's price. While nearby some buyers may view nearby open space as a desirable amenity, vacant residential parcels in the city are rarely well-maintained and often the site of illegal dumping. Further, the consistent negative price effect of proximity to vacant parcels may help explain the lack of significance in the measures of exposure to properties showing external signs of disrepair.

In an additional test, I attempt to control for the spatial clustering of both poor-quality housing and arms-length residential transactions by re-estimating my models only including observations in relatively stable neighborhoods. In Table ## I present the results of the same eight regressions with observations limited to census tracts where surveyors assigned F grade to less than 5% of residential properties. In most of these models, the coefficients on the proximity measures increase while the standard errors decrease. Again, in these models, proximity to C-rated properties are associated with the largest declines in sales values, particularly when measured as a dichotomous measure. Finally, in these models the percent of C-, D-, and F- rated properties within 250' of a sale is now a statistically significant predictor of lower sales values.

Table 5: *Regression Limited to Low-F Neighborhoods*

	Dependent Variable: LN(Sales Value)								
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
# D/F wn 250' (Radius)	-0.043***	--	-0.003	--	--	--	--	--	--
	(0.009)		(0.009)						
# D/F btwn 250' & 500' (Radius)	-0.017**	--	-0.019***	--	--	--	--	--	--
	(0.005)		(0.005)						
# D/F btwn 500' & 1,000' (Radius)	-0.007***	--	-0.007**	--	--	--	--	--	--
	(0.002)		(0.002)						
# D/F wn 250' (Synthetic Block)	--	-0.059**	--	0.015	--	--	--	--	--
		(0.020)		(0.021)					
# D/F btwn 250' & 500' (SB)	--	-0.018	--	-0.003	--	--	--	--	--
		(0.015)		(0.015)					
# D/F btwn 500' & 1,000' (SB)	--	-0.022	--	-0.018	--	--	--	--	--
		(0.012)		(0.011)					
# C/D/F wn 250' (Radius)	--	--	--	--	-0.000	--	--	--	--
					(0.003)				
# C/D/F btwn 250' & 500' (Radius)	--	--	--	--	-0.004*	--	--	--	--
					(0.002)				
# C/D/F btwn 500' & 1,000' (Radius)	--	--	--	--	-0.003***	--	--	--	--
					(0.001)				
# C/D/F wn 250' (SB)	--	--	--	--	--	-0.006	--	--	--
						(0.005)			
# C/D/F btwn 250' & 500' (SB)	--	--	--	--	--	-0.001	--	--	--
						(0.004)			
# C/D/F btwn 500' & 1,000' (SB)	--	--	--	--	--	-0.006*	--	--	--
						(0.003)			
Percent of Houses C/D/F wn 250' (SB)?	--	--	--	--	--	--	-0.002***	--	--
							(0.001)		
Percent of Houses C/D/F btwn 250' & 500' (SB)?	--	--	--	--	--	--	-0.001	--	--
							(0.001)		
Percent of Houses C/D/F btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	-0.001*	--	--
							(0.001)		
Any C/D/F wn 250' (SB)?	--	--	--	--	--	--	--	-0.112***	--
								(0.023)	
Any C/D/F btwn 250' & 500' (SB)?	--	--	--	--	--	--	--	-0.025	--
								(0.023)	
Any C/D/F btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	--	-0.032	--
								(0.022)	
Any C wn 250' (SB)?	--	--	--	--	--	--	--	--	-0.115***
									(0.022)
Any C btwn 250' & 500' (SB)?	--	--	--	--	--	--	--	--	-0.020
									(0.023)
Any C btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	--	--	-0.032
									(0.022)
Unit Rated C?	--	--	-0.370***	-0.376***	-0.360***	-0.363***	-0.337***	-0.345***	-0.344***
			(0.025)	(0.025)	(0.026)	(0.026)	(0.027)	(0.026)	(0.026)
Unit Rated D	--	--	-0.735***	-0.757***	-0.743***	-0.739***	-0.705***	-0.726***	-0.727***
			(0.057)	(0.057)	(0.056)	(0.056)	(0.057)	(0.056)	(0.056)
Unit Rated F?	--	--	-1.140***	-1.155***	-1.155***	-1.149***	-1.109***	-1.137***	-1.135***
			(0.098)	(0.098)	(0.097)	(0.097)	(0.097)	(0.097)	(0.097)
Census tract fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year of sale fixed effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter of Year Sale Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	14,324	14,324	14,324	14,324	14,324	14,324	14,324	14,324	14,324
Adjusted R-sq	0.399	0.397	0.417	0.416	0.417	0.416	0.416	0.417	0.417
ll	-19908.540	-19935.553	-19694.589	-19712.356	-19690.274	-19709.979	-19701.027	-19692.577	-19677.251
aic	40149.079	40203.106	39727.178	39762.712	39718.549	39757.958	39740.054	39723.155	39692.503
bic	41405.648	41459.674	41006.456	41041.990	40997.827	41037.236	41019.332	41002.432	40971.615

It is important to remember that my dataset is cross-sectional, and thus only measures property conditions at a specific point in time. As a unit's condition decays, however, it does so incrementally. A D property today, may have been a C property five years ago. And, especially as units fall into the worst states of disrepair, their TCI rating may be especially ephemeral. D units, without investment, quickly decay to Fs; while F properties are either razed by the city or succumb to fire. Thus, the negative association between vacant parcels and sales values may be picking up the negative impact of a recently demolished D or F unit. I would need additional data on property demolitions, however, to test this hypothesis, but it is consistent with my results.

In sum, the results of my analysis support, but complicate, the hypothesis that housing in poor condition lowers the sales prices of nearby units. My models do indicate, that exposure to moderately distressed C-rated properties is associated with lower sales prices. When I limit my observations to neighborhoods in Cleveland with comparatively few F-rated units, this relationship becomes even more evident.

My results are surprising, however, in that they suggest little association between the worst-conditioned units and sales values. There are, I posit, two possible explanations for this. The first, as I have already discussed, is that buyers may be highly sensitive to the first instance of housing problems in a neighborhood but care less about the intensity of this exposure. The first unit in disrepair may thus absorb most of the price effect of the physical condition of the neighborhood. This is consistent with my results. Yet, it is still surprising that this does not hold for the housing units in the worst physical condition—those rated D or F. I only identify this association when I include C-rated properties in my proximity measures.

A second explanation is that there are problems with my research design which inhibit my ability to measure the price effects associated with housing conditions. In short, the models I have presented do not solve the reflection problem. Housing conditions likely affect housing prices, but prices also likely affect housing conditions. With cross-sectional data, I can observe this association, but I unable to isolate the causal nature of the relationship. That I find an association between exposure to moderately-distressed C-rated properties and sales values, while controlling for neighborhood and unit characteristics, does suggest that neighborhood housing conditions do contribute to property sales values. But without better data, it is difficult to say more about the nature of this association.

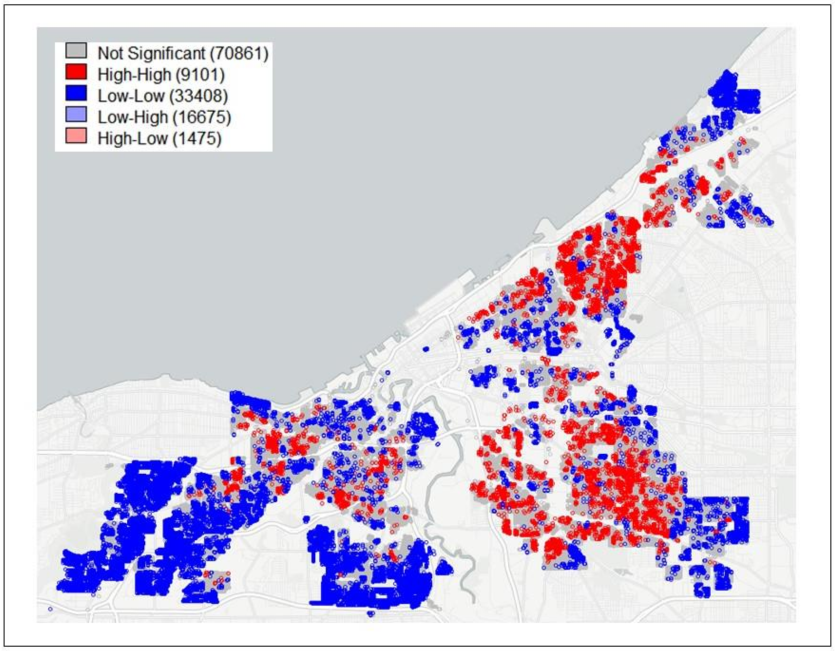
Although the reflection problem poses a clear empirical challenge for my research, that it may exist in the context of the spatial distribution of housing problems and sales value is an interesting and potentially policy-relevant observation in and of itself. In this project, I am interested in whether, and through what channels, poor-conditioned houses affect their neighborhoods. One way to observe this influence is by measuring, as I have done in this section, the influence of exposure to poor-condition housing on sales values. But if this effect does indeed exist, we should also expect to see a strong spatial clustering of houses by their physical condition.

Of course, these patterns would exist if it were completely exogenous factors that caused the spatial distribution of houses by quality and price. If, for example, historical racial stigma caused systemic underinvestment in certain neighborhoods, we would expect that the housing in these areas would be both inexpensive and poor-quality. But my research design allows me to test whether these associations exist even controlling for larger neighborhood characteristics. It is this question I turn to in the remainder of this analysis.

Does exposure to poor-conditioned housing units impact the likelihood of physical disrepair?

If in Cleveland the presence of poor-conditioned housing units does indeed impact the condition of other houses in the neighborhood, I should observe two phenomena in the city's housing stock. The first is a strong spatial clustering of housing units in similar physical condition. The second is an association between poor physical conditions and exposure to poor-conditioned units. Spatial clustering alone is a necessary, but not a sufficient condition for the property conditions contagion effect I hypothesize. If D or F properties tend to be in the same neighborhoods, this could be evidence that the process of self-fulfilling expectations that Bradbury et. al. (1982) describe has already occurred in these places. But of course, there are a host of other unrelated external factors that could also explain this observed clustering. A neighborhood's proximity to an industrial park, or simply the age of its housing stock, may also influence the condition of its housing and have little to do with the dynamic I am interested in here. The likelihood measure, though still imperfect, lends more support to the causal nature of this relationship. If the condition of a unit influences the condition of its neighbors, I expect that exposure to units in disrepair will increase the likelihood of any unit itself being in a state of disrepair.

Map 3: *LISA Map of Unit Conditions*



Housing units in Cleveland are clustered by physical condition. Just as there is a strong demographic east-west divide in the city, so too do characteristics of housing stock follow roughly this spatial division. As **Map 1** shows, most D and F rated units are located on the east side of downtown. **Map 3** is a Local Spatial Autocorrelation (LISA) visualization based on a 20 nearest-neighbors spatial weights matrix. The LISA map divides the observations into four categories based on the statistical similarity (or difference) of the observation to that of its neighbors. Here, the outcome variable is dummy measuring whether the survey rated the observation C, D, or F. The low-low group contains observations that the survey did not rate C, D, or F and are located near similar properties. Most of these properties are located on the west side of the city. In contrast, the high-high observations, those rated C, D, or F with similar neighbors, are clustered around downtown and on the east side of the city.

But, just because I observe clustering of units in poor condition on the east side of the city is not itself evidence of the spatial contagion of property conditions I seek to test here. The east-side of Cleveland has long been the location of concentrated disadvantage, poverty, and racially-motivated disinvestment. These factors could, and likely do, contribute to the present-day condition of the housing stock in these neighborhoods. In this analysis, I am interested in the impact that exposure to poor conditioned units has on an observation's likelihood of itself being in poor condition, while controlling, to the best of my ability, for other factors which contribute to the spatial distribution of housing conditions.

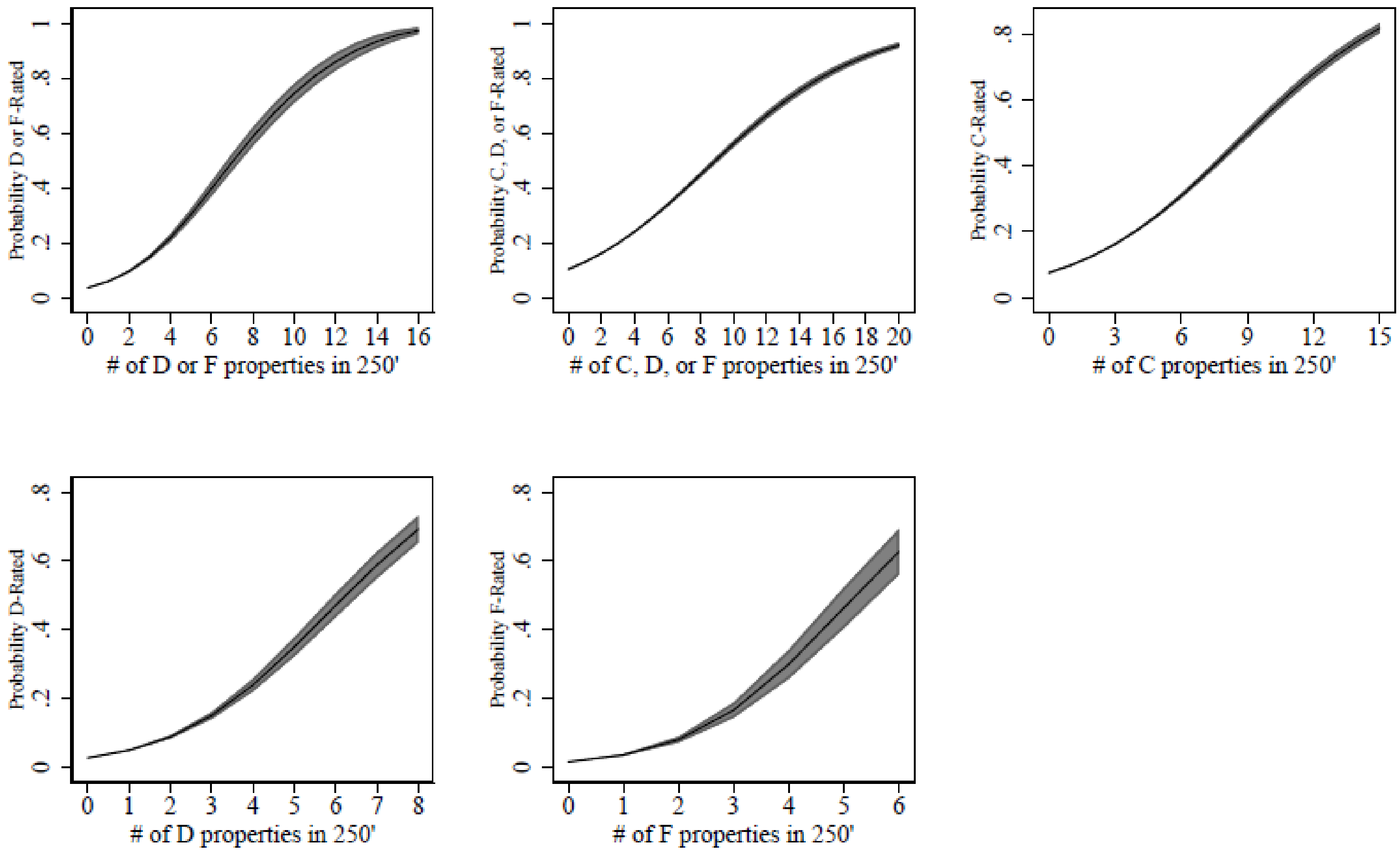
I examine this question by specifying a series of logit regressions in which the outcome is a dichotomous variable measuring whether a unit received a C, D, or F rating in the TCI survey. Like in the hedonic regressions I report above, I control for a series of unit observed characteristics, as well as census tract fixed effects. In all specifications, the primary explanatory variables of interest are counts of proximity to poor conditioned housing units. In these models, while I test both methods of measuring proximity, I only report proximity via my synthetic block measure. Substituting the radius measure in these regressions does not substantially alter my results. **Table 6** shows the results of these regressions and **Figure 2** shows the plotted predicted probability that a house is distressed based on its spatial exposure to similarly-conditioned units.

In the first two specifications, I identify a strong, positive relationship between proximity to units in disrepair and the likelihood a unit itself is in poor physical condition. In Model 1, the outcome variable is a dichotomous measure of whether TCI inventory rated the observation either D or F. In Model 2, I expand the outcome measure to include C-rated units. As the predicted probability plot shows, holding all other variables at their means, a property with no D- or F-rated houses in 250’ has less than a 5% probability of receiving a rating of D or F, while this probability increases to over 95% when a house is exposed to 14 D or F units. In the second, the magnitude of the effect is slightly smaller, but remains statistically significant at 99% level. The observed effect attenuates quickly with distance. In Model 1, both coefficients on the additional two distance bands are much smaller, and neither are statistically significant. In Model 2, surprisingly, an additional C, D, or F-rated unit is associated with a slight decrease in the likelihood of an observation having one of those three ratings.

Table 6: *Exposure Regressions*

	Model 1	Model 2	Model 3	Model 4	Model 5
Dependent Variable	***D or F?***	***C, D, or F***	***C?***	***D?***	***F?***
# D/F wn 250' (Synthetic Block)	**0.569*****	--	--	--	--
	(0.014)				
# D/F btwn 250' & 500' (SB)	0.022	--	--	--	--
	(0.013)				
# D/F btwn 500' & 1,000' (SB)	0.012	--	--	--	--
	(0.010)				
# C/D/F wn 250' (SB)	--	**0.277*****	--	--	--
		(0.004)			
# C/D/F btwn 250' & 500' (SB)	--	**-0.049*****	--	--	--
		(0.004)			
# C/D/F btwn 500' & 1,000' (SB)	--	0.001	--	--	--
		(0.002)			
# C wn 250' (SB)	--	--	**0.303*****	**0.023****	0.022
			(0.004)	(0.008)	(0.013)
# C btwn 250' & 500' (SB)	--	--	**-0.029*****	**-0.053*****	**-0.080*****
			(0.004)	(0.008)	(0.014)
# C btwn 500' & 1,000' (SB)	--	--	**0.012*****	**-0.018****	-0.005
			(0.003)	(0.006)	(0.011)
# D wn 250' (SB)	--	--	**-0.157*****	**0.683*****	-0.033
			(0.014)	(0.017)	(0.032)
# D btwn 250' & 500' (SB)	--	--	**-0.075*****	**0.068*****	-0.042
			(0.012)	(0.018)	(0.030)
# D btwn 500' & 1,000' (SB)	--	--	**-0.026****	**0.041****	-0.033
			(0.010)	(0.015)	(0.024)
# F wn 250' (SB)	--	--	**-0.194*****	-0.017	**0.963*****
			(0.028)	(0.037)	(0.034)
# F btwn 250' & 500' (SB)	--	--	**-0.084*****	-0.017	**0.234*****
			(0.023)	(0.033)	(0.038)
# F btwn 500' & 1,000' (SB)	--	--	**-0.035***	-0.027	**0.179*****
			(0.016)	(0.024)	(0.030)
Census tract fixed effects?	Yes	Yes	Yes	Yes	Yes
N	99,361	109,937	109,931	99,196	74,244
ll	-15513.555	-42215.926	-38537.196	-12616.68	-5406.514
aic	31393.11	84827.852	77480.392	25609.36	11131.029
bic	33132.802	86730.169	79430.736	27396.272	12596.231

***Figure 2**: Margins Plots, Exposure on Distress*



To explore this relationship further, in Models 3, 4, and 5, I estimate the likelihood that the TCI rated an observation either C, D, or F separately. The first thing to observe with these specifications is that units tend to cluster around properties in similar condition. Having a C-rated unit in 250' significantly increases the likelihood that a unit is rated C, as does an additional D- or F-rated unit in 250' increase the likelihood the surveyor rated the unit D or F, respectively. Exposure to D and F properties decreases the likelihood that the surveyor rated the property C. Further, exposure to F properties have no statistical association with the likelihood that the surveyor rated the property D, nor does exposure to C or D increase the likelihood of a property's F rating. As in Model 2, in Model 3, while an additional C unit in 250' increases the likelihood that the surveyor rated the property C, one in the 250' to 500' band slightly decreases this probability. As I discuss more below, C properties may be a harbinger of neighborhood decline, but exist in neighborhoods where this process has yet to manifest fully.

In all five models, direct exposure to vacant parcels is associated with an increased likelihood of a unit showing some external sign of physical disrepair. Again, as in the price effect models, this may be picking up the influence properties that have succumbed either to the wrecking ball or fire before the TCI inventory took place. Unit age is a strong predictor of unit conditions, as are certain characteristics of the unit, such as whether it has central air conditioning or a garage. If the city lists a unit in its rental registry, it is much less likely that the surveyor rated the unit either D or F. But there is no statistically significant association between rental units and C-rated properties.

My models suggest that holding constant neighborhood and unit characteristics, a given house in Cleveland is more likely to be in poor physical condition when exposed to similar houses in its neighborhood. Of course, my design could be missing sub-census tract neighborhood characteristics that may also explain this observed clustering, such as localized crime, pollution, or some other block-level nuisance. The fact that the effect I observe in these models attenuates quickly with distance, however, provides some evidence to the contrary. If my models were picking up the influence of an unobserved block-level characteristic, for example, I would expect that each the three proximity measures would have similarly sized coefficients.

Conclusion and Discussion

Housing problems are a predictable outcome of neighborhood decline, just as a they are an outcome of larger city- and region-wide changes in residential demand. In places where the demand is high, one rarely sees dilapidated housing. When houses do fall into disrepair, developers quickly step in to either renovate or redevelop the distressed house. In these instances, although the value of the structure has dropped, the land on which it sits remains valuable. But in declining neighborhoods, renovations and redevelopment are much less common. Just as it is rare for developers to build new housing in undesirable locations, redeveloping in places where there is little demand for land is, understandably, uncommon. In this way, we might view housing conditions as reflecting (or, at least, strongly influenced by) the value of land.

But it is also possible that housing conditions themselves may influence land values. If the presence of dilapidated housing makes a neighborhood a less pleasant place to live, by lowering demand they can also depress land values. If this is the case, especially in areas that are declining for exogenous reasons, the presence of distressed housing may hasten the cycle of neighborhood deterioration. In this paper, I search for evidence that property conditions can influence neighborhood housing values.

Ultimately, I am unable to fully untangle the relationship between property values and neighborhood housing conditions. The many different, and often unobservable, forces that drive neighborhood housing values in places like Cleveland, make it difficult to isolate impact of exposure to poor-conditioned housing. As I have shown throughout this project, examining this question is difficult due to limitations of the available data. In most cities, there are little, if any, data available on property conditions. These surveys are difficult to administer, expensive, and thus out-of-reach of many already cash-strapped municipalities. Cleveland is unique, however, as thanks to the efforts of TCI, there are reliable data on the spatial distribution of housing problems throughout the city. But cross-sectional data, while useful to give a snapshot of housing problems at a point in time, are less useful in studying how housing problems spread.

Despite these limitations, in this project I do present some evidence that distressed housing harms nearby properties. My models suggest that when houses located near moderately-distressed properties sell at a discount, even when controlling for the condition of the sold unit and its neighborhood. This association appears strongest in neighborhoods where housing problems are relatively rare. My results also suggest that proximity to distressed housing increases the likelihood that a unit has certain housing problems. In the second half of my analysis, I find a that, even controlling for Census tract fixed-effects, exposure to poor-conditioned housing increases the propensity for a unit to have external housing problems.

These findings are useful for planners working in cities like Cleveland as they think about, and design policies to address, poor-quality housing. My results do show that physically distressed housing can produce negative externalities that impact other units in their neighborhood. My first model suggests that in relatively stable, high-quality neighborhoods, the presence of distressed housing does appear to have negative impact on neighborhood sales values. If planners are concerned about stabilizing neighborhoods before they enter cycles of decline, they should intervene early with policies that help owners of moderately distressed properties maintain their units.

But I find little evidence that in neighborhoods where quality problems are pervasive, proximity to housing poor condition has much of a discernable impact on sales prices. As my second test suggests, in these places, any negative price affect associated with this proximity appears to be built-in to the quality of the neighborhood housing stock. These results suggest that, at least to the extent that they are generalizable outside of Cleveland, demolishing the most distressed properties alone will do little to bring declining neighborhoods back. Cities considering demolition programs should either be clear of their goal in adopting these policies—e.g., removing dangerous and unsafe housing—or they should couple them with programs that address the other underlying problems these neighborhoods, and the people who live in them, face.

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CHAPTER 3

DO CONSTRAINTS ON THE DEVELOPMENT OF NEW HOUSING AFFECT THE PREVALENCE OF HOUSING PROBLEMS? EVIDENCE FROM THE AMERICAN HOUSING SURVEY

Introduction

Do constraints on the development of new housing hinder private markets from producing an adequate supply of high-quality, affordable housing? There is a growing consensus among scholars and policy analysts that underbuilding in high-demand markets raises the price of housing (Fernald, 2017). Increased housing prices, in turn, can lead to a host of other social problems, such as—segregation by race (Pendall, 2000) and income (Lens & Monkkonen, 2016), increasing housing cost burdens (Colburn & Allen, 2016), and patterns of neighborhood change and gentrification (Brueckner & Rosenthal, 2009; Ellen & O'Regan, 2011).

Despite a large body of evidence that housing constraints can produce substantial social harm, few scholars have studied the impact that limits on new housing development have on the physical quality of the housing stock itself. This is not to say that scholars and policy makers are uninterested in issues related to the physical adequacy of housing. In fact, questions of whether people occupy housing with certain quality problems and what policy can do to help improve their living situations have been a central concern for urban policy analysts as long as the federal government has intervened in housing markets (Mason, 1982). Despite this rich analytical history, recently the academic and policy focus on questions on the physical quality of the housing stock have waned. One plausible explanation for this shift is that fact that housing quality has improved substantially over the last fifty years ("The State of the Nation's Housing", 2016). These gains are attributable to some combination rising incomes, increasing rates of homeownership, and the effect of building codes and other policies specifically targeting physical housing conditions.

And even though the decrepit tenements long synonymous with urban living in the US are no longer, many households today continue to occupy units with serious physical deficiencies. Scholars have described in devastating ethnographic detail how people coping with chronic poverty have little choice but to accept housing with mold, unreliable utilities, faulting plumbing, and other physical quality issues (Desmond, 2016). But ultimately disagreement about how to measure unit quality, coupled with a lack of reliable data have made studying the pervasiveness of these problems challenging.

In this project, I weave together two research threads—one in which analysts examine the negative economic and social consequences of underbuilding and another in which scholars seek to understand what individual and market characteristics lead people to occupy poor-quality and substandard housing. To study these questions, I examine whether market-level supply constraints affect the likelihood that families in those places live in housing with structural, cosmetic, and mechanical problems. I build a dataset with unit-level data from the metropolitan waves American Housing Survey (AHS) and MSA-level indicators from the US Census and the Wharton Residential Land Use Regulatory Index (WRLURI). I use these data to examine the impact that market-level supply constraints have on the physical condition of housing units.

In my models, I use variation in supply constraints between metropolitan areas to examine how these market conditions influence the physical quality of housing units. I find no evidence that market-level housing supply constraints are associated with an increased prevalence of minor cosmetic issues, larger structural problems, and issues with the heating and electrical systems. In fact, my models suggest that units in housing markets with stricter development regulations are less likely, not more, to have these housing problems. As I show in my final essay, people living in expensive, supply-constrained markets tend to occupy smaller and older units than demographically-similar families living in affordable places. But, because markets where supply-constraints are the most binding are also richer, their housing stocks tend to have fewer housing quality problems than those where it is relatively easy to build.

Background

In this paper, I am interested in whether supply constraints increase the likelihood that people occupy physically deficient housing. This question, although simply stated, is challenging to study because factors that limit new housing development affect markets in three, potentially countervailing ways. First, and perhaps most directly, by making it difficult for developers to build new housing, supply constraints may impact the physical characteristics of a city's housing stock. At minimum, places where it is harder to build new units will have older housing than they would if there were fewer limits on new development. Second, by raising housing prices, constraints affect the choices available to, and behavior of, people as they search for housing. In the face of high housing prices, people may choose to reduce the amount of housing they consume to find an affordable unit. But predicting what this change looks like is difficult, as individuals can change their consumption in many ways. Finally, if supply constraints are binding enough, they can alter the socioeconomic composition of a place in a way that raises average housing quality. Supply constraints, by raising housing prices, can make it difficult for low- and middle-income households to find places to live—making places more uniformly rich. They can also lead the rich to fix-up formerly under-maintained housing. Supply constraints may thus lead to market-wide gentrification. In the remainder of this section, I detail in-turn each of these three forces and the discuss the impact they have on my analysis.

Supply constraints and housing problems?

Constraints on the development of new housing affect the rate at which developers add new units to the housing supply. Where demand for housing is high but it is hard to construct new housing, developers build less. Most directly, this will affect the housing choices of those who would otherwise prefer to live in new housing. While not all housing deteriorates as it ages (maintenance, after all, can offset declines in physical quality), most does (see, for example, [Rosenthal, 2014]). Thus, supply constraints immediately and most directly affect the housing options of households who have strong preferences for new, high-quality housing—relatively high-income families. In places where it is hard to build new housing, some portion of these people who would prefer to live in newly developed housing will be unable to find or afford a unit and continue to occupy their old unit. We should thus expect that in a supply-constrained place because there are fewer new units available, a segment of the population will live in older housing than they would if developers were free to build housing to match demand.

But how does an increase in the average age of the housing affect housing quality? At the top of the market, even though families will live in older units, it is unlikely that they will be more likely to occupy deteriorating or otherwise substandard units. These people may, at least on average, occupy smaller units and houses with out-of-date technology (e.g. window units instead of central air, dated floor plans, etc.). But among the highest income households, it is unlikely that supply constraints will be impactful enough to increase the number of high-income households living in units with mold, peeling paint, or other major housing problems.

Yet, while supply constraints most directly impact the consumption of people who would have purchased or rented the forgone new development, it will also impact the characteristics of housing occupied by middle- and low-income households. Only relatively high-income households ever occupy newly-constructed houses. Most consumers occupy used units—those which have had multiple occupants over time. Thus, although constraints on new development directly affect the supply of housing available to relatively high-income households, by slowing the rate at which these households move into new units, supply constraints also make these people less likely to vacate their old units. This, in turn, slows the rate at which lower income households abandon their old units and so on and so forth down through the housing market. On net, constraints affecting the development of new, high-end housing will mean that everyone in the market will live in slightly older and, perhaps, poorer quality housing than they would if developers faced fewer constraints.

It is worth pausing to briefly consider the process by which private markets produce a housing stock of varied prices and qualities. Or, as Galster (1996) states, “the complex forces that produce an array of dwellings defined by quality and price.” Most households will never be the first household to occupy their unit. Instead, they purchase or rent houses developed for a higher income group that have declined in price and deteriorated in quality as they age. Thus, it is not exclusively the production of new housing that determines the characteristics of the housing stock, but also the process through which the price and quality of existing units change over time. Although housing development is similar, at least conceptually, to the production of other consumer goods, the process through which existing housing units ‘filter’ through the market over time is a relatively unique characteristic of housing (Galster, 1996; Grigsby, 1963; Lowry, 1960).[3]

Even though older houses are, on average, less expensive and of lower quality than new units, not all houses decline in price as they age. We maintain architecturally- or historically-significant homes to stall the filtering process. With enough maintenance, a century-old house may be as expensive, if not more expensive, than a similarly-designed house built today. Further, filtering is not exclusively a monotonic function in which price declines with age, but rather a dynamic process influenced by factors both internal and external to the unit itself. As a result, units can

[3] In most descriptions of the housing filtering process, scholars draw comparisons between markets for housing and those for automobiles. Both are durable goods; both have robust resale markets; and low-income households rarely, if ever, consume new cars or homes. Housing, however, differs from cars in that housing lasts much longer.

filter both *down* and *up* throughout their lifecycle—depending on the direction of the change of the unit's price and quality. Grigsby (1963), building on the work of Lowry (1960), explains that over the life of a unit, filtering occurs due to some external change in the style, technological or locational quality of a house, and the impact that these changes have on its physical condition.

According to Grigsby, as housing ages, its initial change in quality will be due to some factor external to the house itself. An innovation in architectural style or building technology changes the relative quality of an older unit. Of course, it is always possible for the original tenant, if they have the financial means, to renovate their unit and undo this first-wave of obsolescence. But, because it is relatively difficult to update the style of a house or its basic technological attributes (adding central air to house lacking the proper ductwork, for example), it may be easier and less expensive for the original occupant to move to a new unit that more closely matches their preference for housing quality. If the original tenant does not renovate their unit, when they move their house will enter the market at a lower quality stratum, and thus command a lower price, than when they first occupied it. In other words, their unit will have filtered.

This decline in price will also impact the maintenance behavior of the next owner of the property. Assuming the market conditions remain the same, the new owner will also have less economic incentive to maintain their unit. An exogenous change in the relative quality of a unit may be the spark that starts the downward filtering process, but physical deterioration is the fuel which powers subsequent price and quality transitions. As physical quality deteriorates, the price of the unit will continue to decline. And if physical quality falls far enough, the owner will stop investing in even basic maintenance and abandon (or demolish) their unit. Physical deterioration is thus an endogenous process that is "much more a factor of underlying demand factors than of time and climate" (Grigsby, 1963, p. 94). This observation that physical deterioration is more a symptom of changes in demand for a unit than it is an exogenous process is key to understanding how market characteristics will influence physical housing quality.

In sum, given the complex economic process through which markets produce a housing supply of varied unit qualities and prices, one can only speculate on how constraints on new development will affect the quality of (and the prevalence of units with physical problems within) the housing stock. But, at the very least, we should expect that supply constraints will increase the average age of housing units in high-demand cities. Data from the 2016 American Community Survey seems to bare out this out. The median housing unit in San Francisco is 74 years old, compared to just 41 and 39 years old in Atlanta and Houston respectively.

Although constraints on new development may directly affect the age of the housing stock, they also impact competition for housing across the market. Increased competition, alongside limits on new development, raise housing prices. And it is this characteristic of supply-constrained housing markets that will more directly affect the physical quality of an individual household's unit. More competition and higher prices will mean that people must make more tradeoffs when searching for housing. Some may choose to rent or purchase smaller units, others accept units farther out from the urban core, while others may accept units with certain physical quality problems. It is the question of how market constraints may affect housing behavior and choice that I turn to next.

Supply constraints and housing behavior?

While supply constraints may over time increase the age of a city's housing, limits on new development will affect the existing housing stock most immediately by increasing housing prices. And, by making housing more expensive, they may in turn alter the decisions of people searching for housing. But before I discuss how supply constraints affect housing choices, it is worth first noting that there are many reasons why housing may be unaffordable. An increase in incomes, growing economic returns to living in a specific place, and foreign investment in real estate can all raise competition for housing in a city and, by extension, housing prices. But without limits on new development, high housing prices are temporary.[4] In an unconstrained market, high prices incentivize developers to build more housing. New housing development lowers competition for the existing housing stock and, over time, regulates prices. But in markets where it is difficult to build new housing, prices remain high so long as developers are unable to add new units to the market or demand for housing falls.

If constraints on new development make housing more expensive, how might higher prices affect housing choices? And, of interest to my current project, how might increases in prices affect a household's willingness to buy or rent a unit with certain

[4] Even short-term spells of unaffordability can harm families. If high housing prices push low income families out of a neighborhood or city, even if prices regulate over time, it may be unlikely that displaced families will ever move back. Middle and high-income families may be to weather short periods of high housing prices; low income families may not.

physical deficiencies? Generally, when faced with high housing prices, there is one of two ways a household can respond—by changing the amount they spend on housing or by changing the type of housing they consume. If a family spends more on housing, it means they have less income to spend on other purchases (or put into savings). Although policy analysts debate how best to measure housing cost burdens (Susin, 2007), most agree that low-income people in expensive housing markets often spend too much on housing and, as result, have less money available to spend on other necessities (Stone, 2017). From a policy perspective, we may be less concerned about how much higher incomes people spend on housing. But even if high housing prices do not affect these household's expenditures on food, education, or other necessities, they can still skew consumption in a way that could have a negative economic impact.

In expensive housing markets, people may also alter the characteristics of housing they purchase. It is impossible to predict *ex ante* how increased housing prices will affect the characteristics of housing a family will consume. This is because an individual housing unit is an amalgam of various unit and locational characteristics (Dipasquale, 1999). When a family rents a house, they are really leasing access to a particular set of unit characteristics (e.g. size, number of bedrooms, style, etc.) and a particular set of neighborhood characteristics (e.g. access to transportation, schools, etc.). Because housing is such a heterogenous good, there are countless ways in which households might alter their housing choices in the face of high prices. Some people may choose to crowd into relatively small units, while others forgo an extra bedroom or bathroom or updated kitchen. And, perhaps, some people will overlook certain maintenance issues or signs of physical deterioration.

How one changes their housing consumption in response to high prices is itself limited by the existing housing supply. For example, even if a household preferred to rent a unit without a kitchen to reduce their housing expenditure, they are unlikely to find listings for such units (likely because most cities have occupancy laws which prohibit landlords from renting units without kitchens [O'Flaherty, 1996]). The same may be true with unit size. In response to high housing prices, some people may prefer to rent small units in dense developments. And while property owners in expensive markets may divide up single-family houses or large apartments into multiple smaller units to meet this demand, these conversions are expensive and often opposed through the same channels that make new development difficult. Thus, even though a household may prefer a smaller unit over one in disrepair, if the existing housing stock lacks an adequate supply of small units, their only choice (given their price and other preferences) may be to rent a unit in poor physical condition.

Again, it is difficult to predict how exactly households will change their housing consumption in the face of high prices. This is difficult both because housing is such a heterogeneous good and because what is available in the existing supply itself limits housing choices. In expensive cities, people searching for housing likely alter their housing choices in any number of different ways. Some rent farther out from downtown, while others purchase a smaller unit while remaining in a centrally-located neighborhood. In this paper, I am interested in examining one specific response people may make to an increase in housing prices—occupying units in disrepair. But, before I describe the previous research on this question, I must first describe one final way in which supply constraints can affect housing quality—by making cities richer.

Supply constraints and demographic composition?

As I have described thus far, supply constraints, by making it difficult to build new housing, can increase housing prices in the short-run and increase the age of city's housing stock in the long-run. Taken together, constraints may concomitantly increase the prevalence of old, poor quality units and make housing units in disrepair more attractive to people searching for housing in an expensive market. If these two observations hold, I predict that there is a positive association between how constrained a city's housing market is and the likelihood that households in that place would occupy units in poor physical condition.

But this simple hypothesis fails to consider another pathway through which supply constraints can affect housing markets—by increasing the average income of households in a housing market (Gyourko, 2009; Gyourko et al., 2006). If a supply-constrained MSA becomes more uniformly rich, even though the housing stock is older, on average, it could be of higher quality if higher income households (or landlords seeking to attract high-income tenants) invest more in maintenance and renovations on the existing housing stock. If this is the case, I will observe the opposite association between supply constraints and housing quality—where people living in supply-constrained places are *less* likely, because they are richer, to live in poor-quality housing units despite housing in these places being both older and more expensive.

There are two trends that occur in supply-constrained cities that can change the economic composition of their populations. The first trend is that rising housing prices may push low income people out of a city. If they can no longer afford housing, even if they are willing to make sacrifices in terms of size, quality, etc., low- to moderate-income households may ultimately give up on an expensive city and move to a place where housing is more affordable.

The second trend affects not the rate at which people leave a place, but rather the socioeconomic composition of new migrants into a city. There are likely many reasons why people, even when confronted with high prices, are unwilling to leave a market (family and social ties, jobs, etc.). But for potential in-migrants, economic considerations may weigh more heavily in their decision. Thus, while scholars debate how supply constraints affect residential displacement (Edlund, Machado, & Sviatschi, 2015; Newman & Wyly, 2006), especially at the market level, most agree that rising housing prices affect the income diversity of in-migrants (Ellen & O'Regan, 2011; Frey, Liaw, Xie, & Carlson, 1996; Ganong & Shoag, 2017). Even without displacing existing middle- and low-income households, over time, supply constraints can still raise the average income of a city.

But how might rising incomes affect the physical quality of the housing stock in a market where it is difficult to develop new housing? As I have discussed above, people in supply-constrained cities on average live in older housing. And they may very well live in smaller units or houses lacking certain amenities. But if for higher-income people, high housing quality is more important than size, age, or certain amenities (a unit with a yard, for example), as incomes rise, so too might the average level of quality in a place. This observation comports with neighborhood-level observations in so-called gentrifying places. For example, Helms (2003) finds that in built-out neighborhoods, when housing prices rise, rates of renovations on the existing housing stock increase. As a result, in the most constrained places, there may be an inverse relationship between average unit quality (and the absence of certain housing problems) and supply constraints—with underbuilding acting to channel more money into renovations of old, poor-quality housing.

In sum, it is difficult to predict how constraints on new development will affect both the overall quality of housing units in a market and the presence of houses with certain physical problems. This is because constraints on new housing development produce countervailing forces which concomitantly make the existing housing stock older and more expensive, while at the same time raising average incomes and, perhaps, in doing so, residential demand for higher quality units. In this project, I provide an empirical test that, while not causal, provides some evidence for which of these two forces more directly affects housing quality in supply-constrained markets. To state my hypotheses more concretely: I expect that supply constraints are associated with an increased likelihood of households living in units with physical quality problems, but that the upward pressure that supply constraints place on local incomes will mediate this association. Before I describe my data and methodology, I next turn to a brief discussion of the previous empirical research on housing quality.

Empirical Research on Housing Quality

While there is no previous empirical scholarship to my knowledge that directly tests how housing supply constraints impact the physical condition of housing units, there is a large literature examining factors associated with physical dwelling quality. Kutty (1999), for example, uses data from the AHS to study what unit and occupant characteristics are associated with an increased likelihood of a family living in an inadequate housing unit. Kutty uses a HUD-measure of housing inadequacy based on a series of AHS unit-quality questions. I discuss this measure more in the data and methodology section of this paper. She finds that unit age is strongly associated with substandard conditions as are unit location, occupant race, tenure, income, and unit crowding. Mundra and Sharma (2009), using data from a more recent AHS survey, but using the same measure of unit inadequacy, find associations similar to Kutty. Particularly, they find that black and Hispanic households are much more likely to live in substandard units than whites. While they identify little difference in housing adequacy by nativity status, they find that naturalization substantially improves the housing conditions of immigrant households.

In a related literature, scholars have studied not unit conditions directly, but the factors associated with the maintenance and investment decisions of property owners. Early research in this area focused on the question of why owners in certain neighborhoods stop maintaining their units and, by extension, why certain neighborhoods decline. Scholars find that property maintenance and upkeep is negatively associated with certain unit characteristics, neighborhood vacancy rates, and other measures of neighborhood quality (Boehm & Ihlanfeldt, 1986; Mendelsohn, 1977; Shear, 1983; Spivack, 1991). Gyourko and Siaz (2004) focus on how the relationship between housing prices and the cost to construct new units influences owner maintenance. They find that the owners of properties valued under their replacement cost spend fifty percent less on maintenance and renovations.

In more recent research, scholars interested in maintenance behavior have shifted their focus from the question of why owners stop investing in maintenance, to why they start. These questions fit within the larger literature on neighborhood change and gentrification. In the study I mention in the previous section, Helms (2003) uses property-level data from Chicago to examine which unit and neighborhood factors increase the likelihood that property owners will renovate their houses. In addition to neighborhood density, he finds that proximity to the central business district, the presence of certain neighborhood amenities (e.g. proximity to parks and Lake Michigan), and unit characteristics such as age, tenure, and vacancy status are all positively associated with renovation expenditures. Other scholars using different methods have arrived at similar conclusions (Munneke, 1996; Rosenthal & Helsley, 1994).

The empirical literature closest to my present analysis test the logic undergirding housing filtering models. As I explain in the previous section, there are several widely-cited studies which offer a theoretical explanation of factors that influence the price and quality transitions of housing units as they age (Braid, 1981; Grigsby, 1963; Lowry, 1960; Rothenberg, Galster, Butler, & Pitkin, 1991). There are, however, relatively few empirical tests of whether, at what rate, and under what conditions housing prices depreciate as they age, and fewer still that examine the physical deterioration that occurs as part of the filtering process. Mayer and Somerville (2003), based on an earlier study by Somerville and Holmes (2001), examine how market supply constraints—measured as direct restrictions on new development and supply elasticity—impact the existing affordable housing stock. They find that in metropolitan areas where it is more difficult to build new housing, units that were previously affordable are more likely to experience an increase in rents (or, put differently, to filter up). Although he does not test supply constraints directly, Rosenthal (2014) finds evidence that the incomes of residents in older rental housing is considerably lower than that of those living in newly constructed rental units. He also finds that age-related price depreciation in rental housing is slower in markets where housing prices are increasing. Although housing prices may rise for reasons other than supply constraints, researchers have identified a strong association between housing price inflation and supply elasticity (Glaeser, Gyourko, & Saks, 2005; Saiz, 2008).

Weicher , Eggers, and Moumen (2013) find that nearly half of the rental housing stock affordable to very-low income households in 2013 had been either owned or rented by higher-income households in 1985. Although their focus is more on affordability than unit conditions, they also provide comparisons between the quality of units based on whether, and in what direction, the unit filtered over this period. They measure quality using the AHS measure of unit adequacy as well as a quality index proposed in Eggers & Moumen (2013) which I use of a version of in this paper. They find that although low-income rental units tend to be lower quality than those occupied by higher-income households, they are in slightly better condition than the stock of units that were consistently low-income-occupied over this period. Filtered units, in other words, tend to be in better condition on average over the period through which they have undergone the downward price transition. Importantly, however, their study does include an analysis of the terminal quality of units at the end of the filtering process. Thus, it is difficult to know based on their analysis whether these filtered units are better quality than the existing low-income rental stock when they reach low-income renters.

Finally, perhaps the most direct tests to-date of the impact of supply constraints on housing conditions are a pair of studies which examine how new construction impacts the physical condition of housing units at the very bottom of the housing market. Vitaliano (1983) in his study of housing markets in New York State, found that the rate of new housing construction had no discernable association with the number of dilapidated housing units fifteen years later. Weicher and Thibodau (1988), however, using a more detailed measure of poor-conditioned housing, found a strong association between new development and the number of households living in substandard units. Using Census data from 59 SMSAs, they estimate that for each new unit added to the market in the 1960s there is one fewer substandard housing unit occupied in the 1970s. Both studies, however, use imperfect measures of housing conditions. While Weicher and Thibodeau use more detailed series of quality questions, like those asked in the AHS, both studies only study the impact that development has on the very worst units in the market.

In summary, while previous housing researchers have long been interested in the impact that supply constraints have on characteristics of the housing stock, most have focused on how constraints affect affordability rather than physical housing quality. The few scholars who have looked specifically have housing quality, have faced challenges with data availability and measurement. In this project, I improve on these previous studies in two primary areas. First, I focus directly on how limits on the development of new housing affect the physical quality of the housing stock. Second, I improve on previous studies by testing various measures of unit quality. In the next section, I discuss my methodology and data, including a detailed explanation of the quality measurements I use in this paper.

Empirical Strategy

In this paper, I examine the association between unit quality and the characteristics of housing market in which those units are located. As I have discussed in detail above, estimating the determinants of housing quality is challenging because unit quality is determined by a series of different unit-, occupant-, neighborhood-, and market-level characteristics. I attempt to isolate the independent influence of these various factors by estimating a series of models predicting the unit-level quality based on indicators of market-level supply constraints, while controlling for a series of observed unit, occupant, and market characteristics as well as time and region fixed-effects. This design does not allow me to examine the causal nature of any of these relationships. I can only interpret the coefficients in my models as associations. In this section I describe the data I use in this analysis, I then move to a discussion of results.

Data

In this analysis, I rely primarily on data from two waves, 2011 and 2013, of the metropolitan samples of the AHS conducted by the Census bureau. Waves of the metro AHS occur about every two years, with individual metro areas re-surveyed approximately every sixth year (there is, however, significant variation in the frequency of re-surveys). Like the national AHS, the metro sample follows individual housing units longitudinally, although the Census bureau adds and removes units with each wave to ensure the continued representativeness of the sample. During my study period, the AHS surveyed 54 metropolitan areas.

Appendix 2 shows the metro areas included in my dataset, when the Census bureau included them in the AHS, and the sample size. In total, my dataset includes 121,123 unit-year observations across 54 metropolitan areas and 2 AHS waves. While I include some vacant (but, importantly, not abandoned) units in my market-level calculations, I exclude most of these units from my analysis since these observations are often missing important data on unit- and occupant-characteristics (a vacant unit, after all, does not have an occupant whose income, race, etc. I can control for).

Ultimately, the strength of my analysis rests on my ability to accurately measure two variables. The first is the presence of certain housing problems. Housing scholars have long been interested in developing a single indicator of housing quality (Goodman, 1978). But by most accounts, the complex and multifaceted nature of housing quality makes developing a single, internally consistent metric nearly impossible (Newman & Garboden, 2013). I do not wade into this discussion. Instead, I test several different measures of quality, while acknowledging that each one measures only a component of overall housing quality.

The second variable is a measure of housing market supply constraints. Like with housing quality, scholars have grappled with the challenge in developing a single measure of housing supply constraints that is comparable across metropolitan areas (Glaeser & Ward, 2009). While several scholars have made significant advancements towards this goal, the field is still without a single metric to measure constraints on the development of new housing. As with unit quality, in this analysis I do not seek to advance this debate, but instead use multiple existing measures of supply constraints.

Housing Quality

As I explain above, the primary challenges confronting researchers interested in the determinants of housing quality lies in definition and measurement. Among analysts using data from the AHS, there are three primary ways that previous researchers have attempted to measure unit quality. Probably the most common method, especially among studies of poor housing conditions, is to use the AHS inadequacy measure, ZADEQ (Kutty, 1999). The Census Bureau has included this variable in both the metro and national samples of the AHS over the last 30 years, and it closely mirrors the US Department of Housing and Urban Development's (HUD) internal definition of housing adequacy. While some scholars have raised questions about the design and internal consistency of ZADEQ (Emrath & Taylor, 2012), it is still one of the most commonly used measurements of severe housing problems (Fernald, 2017).

One of the primary critiques of the ZADEQ measure, and others like it, is that it seeks to reduce the complex and multifaceted concept of unit adequacy into a single ordinal variable. As a result, it is bound to be either overly precise or overly imprecise in its measurement of unit problems. In response, other researchers also using data from the AHS, have created an index of unit quality/problems which they argue incorporates the richness of data available in the AHS more fully (Eggers & Moumen, 2013a). They argue that their Poor Quality-Index (PQI) more completely captures the spectrum of potential housing problems but does so in a single comparable variable.

While in previous versions of this paper I attempt to use versions on the PQI in this analysis, I ultimately find that the index is not reliable enough to use an outcome variable in multiple regression analysis. Further, although the PQI is useful to *generally* measure severity of physical housing problems—the higher a unit's PQI score, the worse its physical condition—it is difficult to practically interpret marginal movements along the index. For example, a unit receives a PQI score of 10 if there were multiple breakdowns in the heating system since the last survey, or if it completely lacked electricity. While both problems are cause for concern and, perhaps, a policy response, it is unconvincing to me that these two problems are comparatively severe.

Ultimately, I find both the ZADEQ and PQI measures of housing problems poorly-suited for my present analysis. While it is understandable that researchers want to distill the complex nature of housing quality to a single comparable measure, it may be conceptually easier, and analytically more precise, to measure quality based on the presence (or absence) of specific unit features or problems. Instead, in this analysis, to measure unit quality I create a series of dummy variables measuring whether a unit has a problem in one of six areas of housing quality— whether a unit has any problems with heating or insulation (Freezing), whether it has cosmetic problems such as peeling paint or minor cracks (Cosmetic), whether the unit has severe structural problems (Structural), and whether there are problems with the unit's electrical system (Electricity). In **Table 7**, I list each of these dummy measures and the AHS questions on which they are based.

Table 7: *Quality Dummies*

AHS Question	**Quality Dummy?**
Unit has exposed wiring	Electricity
Each occurrence of a blown fuse or thrown circuit breaker	Electricity
Unit was uncomfortably cold for 24+ hours	Heating
Each heating equipment breakdown	Heating
Holes in the floor	Cosmetic
Open cracks wider than a dime	Cosmetic
Peeling paint larger than 8 by 11 inches	Cosmetic
Roof missing shingles/other roofing materials	Cosmetic
Outside walls missing siding/bricks/and so on	Cosmetic
Windows broken	Structural
Holes/cracks or crumbling in foundation	Structural
Roof has holes	Structural
Roof's surface sags or is uneven	Structural
Outside walls slope/lean/slant/buckle	Structural

Source: All data are from the AHS.

Supply constraints

For researchers studying housing markets dynamics, determining how to best to measure supply constraints in a way that allows comparison across cities and metropolitan areas poses a perennial challenge. Cities have a wide array of regulatory tools at their disposal with which to limit the development of new housing. While one city may control development through an onerous approval and permitting process, another may directly control density through minimum lots size requirements or floor-area ratios.

Table 8: *Variables*

Unit/Occupant Controls	Source	Min	Max	Avg.
Rating of neighborhood as place to live (10 is best; 0 is worst)	AHS	0	10	7.9
Age of Unit	AHS	0	95	42.5
Unit occupied by a white household? (1 yes; 0 no)	AHS	0	1	0.7
Household contains children under the age of 18? (1 yes; 0 no)	AHS	0	1	0.5
Unit located in central city of MSA? (1 yes; 0 no)	AHS	0	1	0.3
Unit located in single family structure? (1 yes; 0 no)	AHS	0	1	0.5
Number of bedrooms.	AHS	0	10	2.6
Does the Federal, State, or local government pay some of the cost of the unit? (1 yes; 0 no)	AHS	0	1	0.0
Metro-Level Variables				
WRLURI	Wharton	-1.23	1.94	0.2
Rental Vacancy Rate	AHS	10.5	2.98	19.16
Avg. HH Income, 2015	ACS	81379	63944	128243
Pct. Change in Employment 2000-2015	ACS	4.1	-1.98	10.94
Pct. Change in Population 2000-2015	ACS	5.15	-1.4	11.6
Dependent Variables				
Cosmetic?	AHS	0	1	9.4%
Structural?	AHS	0	1	5.1%
Heating?	AHS	0	1	5.7%
Electricity?	AHS	0	1	6.3%

For my purposes, I am less concerned with the specific flavor of development regulations that are in place in each city, than I am with whether housing markets exhibit signs of constrained supply. Over the last three decades, several scholars have attempted to produce comparable measures of land use and other housing development regulations (Glaeser & Ward, 2009; Pendall, 2000). While each of these measures has its relative strengths and weaknesses, only one of which I am aware allows for comparison across metropolitan areas—the Wharton Residential Land Use Regulation Index (WRLURI).

The WRLURI is an index of regulatory restrictiveness based on a 2005 nation-wide survey of planners and local government officials (Gyourko, Saiz, & Summers, 2008). The survey gathered data on the various ways in which cities regulate new housing development, including—approval delays, design restrictions, and minimum lot size requirements. The authors then use factor analysis to develop a comparable measure of regulation restrictiveness, the WRLURI. In addition to individual city-level indexes, the authors provide market weights which I use to calculate MSA-level averages. For most of the MSAs in my study, the dataset has responses from the central city in the MSA, as well as at least nine of its suburbs. However, several MSAs in my sample have data on fewer than ten cities within an MSA. Although I still calculate the averages for these markets, I am careful to test the reliability of the measures in my regression analysis. In addition to the problem with under-responses in certain MSAs, one of the primary drawbacks with using the WRLURI is that data are only available in 2008. Thus, in the models in which I use the WRLURI to measure market-level supply constraints, I limit my analysis to only the most recent waves of the AHS.

Other Data

In all models, I control for a series of unit, occupant, and market characteristics based on responses in the AHS. In **Table 8**, I provide a description of each variable as well as its source. I predict that relative quality of a housing unit will be associated with certain occupant, unit, neighborhood, and market-level characteristics. At the occupant-level, I expect that household's income, race, family composition, whether the household receives a government subsidy, housing costs, and unit tenure will each have an independent association with the condition of the unit. Most of these measures are based directly on responses in the AHS. With household income, however, I measure whether the household earns less than 70% of the area median income (AMI). Only the most recent AHS waves include the HUD-reported AMI measure. For consistency across surveys, I manually calculate each MSA's AMI, using weighted reported household income in the AHS.[5] At the MSA-level, I control for average household income, a dummy for whether the MSA lost population between 2000 and 2010, the rental vacancy rate, and the percent change in population and employment between the 2000 and 2010 ACS.

[5] These measures are highly imperfect. The AHS metro waves are representative of the housing units in market, not of its population. Thus, using the AHS survey weights to estimate population characteristics is methodologically questionable. Acknowledging this, I spot check my estimates against HUD-reported AMIs and find that they consistently more conservative (e.g. lower) than the HUD measures. As a result, my 70% AMI variables are likely missing some families with incomes that meet these HUD income limits.

Table 9: *Comparisons Between Low- and High-Constraint Metros*

	All Households		
	All Metros	**Top Quintile WLURI (Most Restrictive) (1)**	**Bottom Quintile WLURI (Least Restrictive) (1)**
% Cosmetic	11%	10%	11%
% Structural	5%	6%	9%
% Electrical	8%	6%	5%
% Heating	8%	8%	7%

	Units Occupied by Households Earning Less Than 30% Area Median Income		
	All Metros	**Top Quintile WLURI (Most Restrictive) (1)**	**Bottom Quintile WLURI (Least Restrictive) (1)**
% Cosmetic	16%	15%	12%
% Structural	8%	11%	8%
% Electrical	7%	5%	5%
% Heating	10%	9%	9%

Note: All averages and percentages based on metro weights in the AHS.

How do supply constraints affect unit quality?

In **Table 9**, I present weighted group averages comparing all 45 metropolitan areas in my sample to those in the top and bottom quintiles in terms of WRLURI scores (a higher score indicates higher constraint). Because the index is based on data from 2008, I limit the quality averages to data from AHS waves completed later than 2010. I calculate these group averages twice. In the top panel of **Table 9**, I include all occupied housing units; in the bottom panel, I limit the averages to units occupied by a household with a total household income less than thirty percent the metro-area median income. I use the thirty percent threshold as it is a common measure of housing cost burdens.

As the top panel shows, among all units in my sample, there is little difference between the average unit qualities in the least- and most-restrictive metropolitan areas based on the WRLURI. Counter to my hypotheses, houses in the least restrictive metros appear to have slightly *more* housing problems than do the most restrictive places. However, when I limit the sample to only low-income households, the results flip—low-income households, on average, appear to live in slightly worse housing in tightly constrained markets than they do units in the least constrained places. The results hold for most measures of housing problems. Across all categories, even where differences exist, they tend to be economically quite small—with differences of, at most, only a few percentage points.

I next specify a series of models testing the association between my two measures of supply constraints and various housing problems, while controlling for other factors that may increase the likelihood of a unit having quality problems. In all my specifications, since the outcome variable of interest is a dichotomous variable measuring whether the observation (unit) has a housing problem. In each specification I control for unit and occupant characteristics which I predict may also impact whether there are problems present in each unit. My unit controls include dichotomous measures of whether the unit receives a subsidy through a government low-income housing program, is renter occupied, is in the central city of its MSA, and a single-family unit. I also include a unit-level continuous measure of the number of bedrooms in the unit and a quadratic term for unit age.[6] My occupant controls include dichotomous measures of whether the household head identifies as white and if the household includes children under the age of eighteen, as well as continuous measure of housing costs and an ordinal assessment by the household head of the desirability of their neighborhood. At the MSA-level, I control for whether the observation is in a declining city, the MSA's average household income in 2015, and the percent changes in employment and population between 2010 and 2015. In all specifications, I also include fixed effects for the survey year and the census region (West, Midwest, South, and Northeast).

In **Table 10** I present the results of my regressions testing the association between a market's WRLURI score and the likelihood units have a cosmetic, structural, heating, or electrical problems. My models suggest a negative and statistically significant association between an MSA's WRLURI score and the

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[6] I use a quadratic term for unit age as scholars have found that there exists a good deal of survivorship bias in housing markets. We tend to think of very old units as being desirable because of their oldness, but, it may be that units are old (in other words, they were never torn down) because they have always been desirable.

likelihood the unit has either cosmetic or a structural problem. To ease with the interpretation of these coefficients, in **Figure 3** I plot the results of a margins analysis in which I estimate the predicted probability of a unit having either a cosmetic or structural problem while holding all the other variables in my models at their averages.[7]

As the plots show, my models suggest the opposite association than I expected between a metro's WRLURI score and the likelihood that a unit has either a cosmetic or structural problem. For example, my models suggest that the statistically average unit in least constrained market in my sample has around a 10% probability of having a cosmetic problem and a less than 9% probability in the most constrained market in my sample. Although these effects are economically quite small, they are statistically significant (95th and 99th-levels respectively).

[7] The interpretation here is a little difficult since my models include time, regional, and SMSA fixed-effects. Thus, by holding the covariates in my model to their mean, I am also controlling for the average-effect of each of the fixed effect variables on the outcome. This caveat aside, this exercise still helps visualize the independent effect of supply constraints on the likelihood of a unit having these various housing problems.

Figure 3: Predicted Probabilities

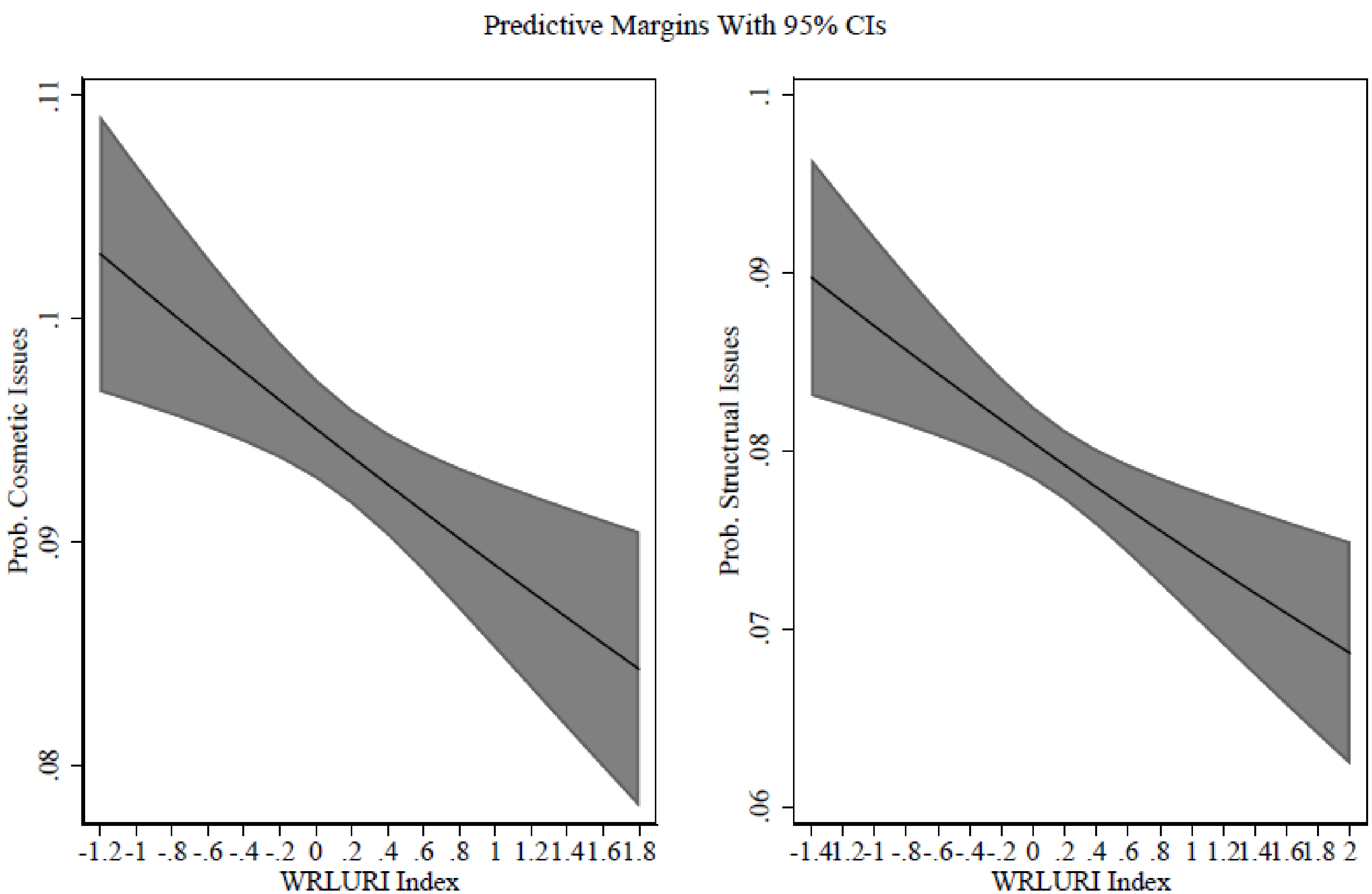

Table 10: *Logit Regressions, WRLURI*

	(1) Cosmetic Problems	(2) Structural Problems	(3) Heating Problem	(5) Electrical Problems
WRLURI	**-0.076****	**-0.090*****	0.038	-0.012
	(0.024)	(0.027)	(0.024)	(0.029)
Declining MSA?	**0.095***	-0.065	**-0.325*****	0.055
	(0.047)	(0.052)	(0.051)	(0.058)
Average HH Income, 2015	**-0.000*****	**-0.000*****	**0.000*****	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Vacancy Rate, Residentai	**0.013***	0.010	**0.029*****	0.009
	(0.006)	(0.006)	(0.006)	(0.007)
Pct Chng Population, 2010-2015	-0.000	0.007	**-0.059*****	-0.003
	(0.010)	(0.011)	(0.011)	(0.012)
Pct. Jobs, 2010-2015	**0.046*****	**0.021***	**0.031****	0.009
	(0.010)	(0.010)	(0.010)	(0.012)
HH Has Income < 70% AMI	**0.223*****	**0.334*****	**0.268*****	-0.019
	(0.030)	(0.032)	(0.032)	(0.038)
Recieves Subsidy?	**-0.215****	**-0.623*****	**0.307*****	-0.171
	(0.075)	(0.119)	(0.068)	(0.087)
Renter Occupied?	**-0.092***	**-0.504*****	0.042	**0.245*****
	(0.038)	(0.050)	(0.041)	(0.045)
Year Structure Built	**0.022*****	**0.027*****	**0.016*****	0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Year Structure Built ^ 2	**-0.000*****	**-0.000*****	**-0.000*****	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Unit White Occupied?	**-0.186*****	**-0.144*****	**-0.280*****	-0.002
	(0.033)	(0.037)	(0.035)	(0.042)
Unit Located in Central City?	**0.069***	-0.024	**-0.154*****	0.006
	(0.030)	(0.034)	(0.033)	(0.038)
Kids in Unit?	**0.348*****	**0.362*****	**0.183*****	**0.299*****
	(0.029)	(0.031)	(0.032)	(0.036)
Neighborhood Rating?	**-0.156*****	**-0.127*****	**-0.116*****	**-0.092*****
	(0.006)	(0.007)	(0.007)	(0.008)
Single Family Structure?	**0.229*****	**0.872*****	**0.168*****	0.073
	(0.043)	(0.063)	(0.045)	(0.050)
# of Bedrooms	**0.053****	**0.073*****	**0.065*****	**0.139*****
	(0.017)	(0.018)	(0.018)	(0.021)
Census Region 2?	**-0.111***	**0.159****	**-0.280*****	-0.049
	(0.050)	(0.057)	(0.048)	(0.059)
Census Region 3?	-0.023	**0.255*****	**-0.455*****	**-0.133***
	(0.050)	(0.057)	(0.048)	(0.059)
Census Region 4?	-0.039	**0.287*****	**-0.118***	0.129
	(0.060)	(0.067)	(0.060)	(0.071)
2013 AHS?	**-0.174*****	**-0.256*****	**-0.342*****	-0.066
	(0.031)	(0.033)	(0.037)	(0.039)
Constant	**-1.965*****	**-2.978*****	**-2.886*****	**-2.982*****
	(0.163)	(0.182)	(0.171)	(0.198)
N	121,123	121,123	121,123	121,123

Standard errors in parentheses: * p<0.05 ** p<0.01 *** p<0.001

Conclusion and Discussion

Housing is expensive in growing cities where it is difficult to build. The populations of both San Francisco and Houston have grown over the last two decades, but over this period median gross rents in San Francisco have increased by nearly 25%, while those in Houston have grown at a moderate 9%. Are high housing prices the only consequence of underbuilding? Or do the housing stocks of places like Houston and New York differ in other ways as well? In this essay, I test whether strict regulations on new development (as measured by the WRLURI) are associated with not only increased housing prices, but also an increased prevalence of certain problems in the housing stock. Using housing data from the AHS, market-level controls from the ACS, and development regulation data from the WRLURI, I find no evidence that development restrictiveness is associated with increased prevalence of heating or electrical problems. Further, my models suggest a small negative association between an MSA’s WRLURI score and the likelihood that a unit has a cosmetic or structural problem.

These results are especially surprising as they cut against the findings of my third essay, in which my models suggest that people in the most expensive, supply-constrained markets are more likely to occupy old units, those with certain problems, those lacking amenities like central AC and in-unit laundry facilities, and crowded housing. What explains these counter-intuitive results?

First, the WRLURI may be an inadequate measure of constraints on new housing development. There are many ways in which local governments regulate new housing development. Although the WRLURI goes farther than any previous attempt to measure development regulations, it is nonetheless possible that misses important ways in which local governments restrict new housing production.

Second, even if the WRLURI is an effective measure of regulatory restrictiveness at the city-level, it may be less effective at measuring supply constraints (and the impact these restrictions have on housing) when used at the MSA-level. While general levels of housing constraints likely do vary across metro areas, they also certainly vary within them. Even in relatively unconstrainted markets, like Atlanta or Houston, some cities, especially wealthy suburbs, restrict development, while others are more permissive to new housing. Thus, measuring supply-constraints only at the MSA-level may miss important ways that restrictions on housing vary between different municipalities within the same metro area. Unfortunately, the AHS data are only available at the MSA-level.

Finally, in this essay I only examine the prevalence of certain housing problems. As researchers have shown, housing quality problems are difficult to measure and the AHS, which relies on occupant responses, may be particularly ill-suited to this task (see, for example, [Newman & Garboden, 2013]). Further, just focusing on housing problems may miss other ways in which constraints on new housing development affect a place's housing stock. For example, supply constraints may also influence housing unit age, crowding, and the prevalence of certain amenities. In my final essay, I attempt to address some of these shortcomings by employing a different empirical strategy and examining wider set of housing characteristics.

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CHAPTER 4

IT'S NOT MUCH BUT AT LEAST IT'S AFFORDABLE: HOW MARKET-LEVEL SUPPLY CONSTRAINTS AFFECT THE PHYSICAL ATTRIBUTES OF HOUSING PEOPLE OCCUPY.

Introduction

Los Angeles County gained around 500,000 jobs over the last five years but approved only 87,000 permits for new housing units. In San Francisco things are not much better, with 77,000 jobs, but only 18,000 permits.[8] Similar trends are occurring in large, high-demand cities across the country. And in places where demand for housing eclipses supply, increased competition for the existing housing stock causes housing prices to rise. Understanding how people cope with high housing prices in supply-constrained places is thus an increasingly relevant question for practicing planners and housing advocates alike.

In response to the growing affordability problems facing many US cities, researchers have documented how people living in expensive, supply-constrained places manage, or fail to manage, to find housing. Scholars have shown that housing prices affect a family's decision about where to live, which in turn determines their access to employment, the schools they send their kids to, and their exposure to crime

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[8] I base these estimates on data from the HUD SOCDs and State of California's Employment Development Department. At larger geographies, these trends are likely even more stark. In an April 12th, 2018 column in Bloomberg Businessweek, for example, Patrick Clark and Noah Buhayar suggest that California gained 2.3 million jobs state-wide over this period but issued only 480,000 new permits (https://www.bloomberg.com/news/articles/2018-04-12/the-american-dream-is-now-a-backyard-rental).

or other social and environmental problems (Epple & Romano, 2003; Manville & Goldman, 2017; Wood, 2014). Others find that in expensive housing markets, people increase the proportion of their income they spend on housing and, as a result, save less or change their spending on other necessities ("Worst Case Housing Needs", 2015). But there has been little research to-date that examines another important way in which people might alter their housing choices—by changing the characteristics of housing they consume.

In this paper, I examine whether high prices in supply-constrained housing markets affect the physical attributes of housing people occupy. As policy makers debate how to respond to crises of housing affordability, it is crucial that they understand in totality the ways in which high housing prices affect housing consumption. The results of my project, by providing a more complete accounting of the how supply constraints affect people living in these places, can help improve the standing of those advocating for solutions that address problems of housing affordability.

To document how high-housing prices distort housing consumption, I estimate a series of models predicting the likelihood that people occupy housing with certain physical attributes based on their socioeconomic and demographic characteristics. I compare how these associations differ based on whether the observations live in a set of the most expensive, supply-constrained MSAs, with people living in relatively unconstrained and affordable places. Essentially, my design allows me to compare how the housing of demographically-similar households differ based on the housing market characteristics of where they live.

My analysis suggests that living in expensive, supply-constrained housing markets lead people to change the type of housing in several ways. First, I find that across all income groups, but especially among people with incomes above the Area Median Income (AMI), households living in expensive, supply-constrained markets tend to occupy older housing units, and units with certain physical deficiencies. Second, I find that in expensive MSAs, households are less likely to occupy units with central air-conditioning or in-unit laundry facilities. My models do not suggest, however, that people in supply-constrained housing markets are more likely to subjectively rate the quality of their unit poorly but do show a small, but positive association between living in an expensive market and responding that their landlord is responsive to maintenance requests. Finally, my analysis provides some evidence that in expensive MSAs households crowd into smaller units than similar households living in unconstrained housing markets.

The Complexity of Studying Housing Consumption

There are many reasons why it may be difficult to for developers build new housing in a particular market. In cities where land is relatively scare or where steep grades complicate construction, for example, it may be hard for builders to locate sites suitable for new housing (Saiz, 2008). But even in the most geographically constrained markets, a place's natural features can only partly explain why it is difficult to build new housing. In markets where supply constraints are the most binding (think large coastal cities in the US), residential development is difficult primarily due to community and political opposition to new housing (Glaeser & Gyourko, 2014; Gyourko, 2009).

Both the motivation for this opposition, and the way in which communities and local governments act upon it, varies dramatically from place to place. People oppose new housing for many different reasons—because of concerns about how it will raise rents or lower home values (Been, Gould, & O'regan, 2017; Fischel, 2015; Fischel, 2009; Hankinson, 2018), because of concerns about how it will increase congestion or alter neighborhood aesthetics (Manville & Monkkonen, n.d.), or because of unspoken racial or economic biases (Aalbers, 2011; Pendall, 2000). And whatever their underlying motivation, those looking to retard new development have many tools at their disposal with which to do so. At the neighborhood level, concerned community members can protest new development by showing up at community and zoning board meetings or by lobbying local politicians (Pendall, 1999; Schively, 2007). In turn, by adopting restrictive land use regulations, planners and local government officials codify informal anti-development sentiment into building codes and land use laws (Metcalf, 2018).

Regardless of their exact form, in markets where residential demand is high, supply constraints raise the price of housing. As with any good allocated through market mechanisms—scarcity raises prices. In desirable-but-constrained places, population grows faster than the housing stock. As a result, in these places there are more people competing for the same number of housing units, which raises the price property owners can charge for their units. The link between supply constraints and prices has been well-established in the academic and policy literatures. Analysts find higher rents and sales in places where it is difficult to build new housing (Glaeser & Ward, 2009; Kok, Monkkonen, & Quigley, 2014; Saiz, 2010b).

Given the supply constraints raise housing prices, how do people searching for housing in expensive, supply-constrained markets make rent? People facing high prices can respond in one of two ways—they can increase the amount of money they spend on housing or they can decrease the amount of housing they consume. By spending more on rent, people have less money left in their budgets to spend on other goods. Of course, for high-income households, this may not be much of a problem—they may have slightly less to spend on entertainment, but housing prices are unlikely to substantially affect their expenditures on necessities. We tend to be more concerned about how rising housing costs affect the budgets of middle- and lower-income households.

There is some debate among housing analysts about how to measure housing cost burdens, especially among low-income populations (Stone, 2017). But nearly all agree that spending too much on rent can harm the short-term wellbeing and long-term life outcomes of people who do. When low-income households spend more on rent, they have less left over to spend on nutritious food, education, or to put away in savings (Lens, 2017; McClure, 2005). Further, cost-burdened people have less cushion in their monthly budgets to deal with unexpected expenses or a loss of income. As a result, low-income renters who spend a large portion of their income on rent are more likely to experience evictions and forced moves (Desmond, 2015).

While the impact that high housing-cost burdens have on people who experience them is both striking and well-documented, it is only half the story. When searching for housing in places where prices are high, households can also respond by altering the type of housing they consume. What is in equal measures beneficial for household searching for housing and frustrating for housing researchers, because housing is such a heterogeneous good, people can change their consumption in countless different ways. In expensive markets, one family may save on rent by searching for a smaller unit in a high-demand neighborhood, while another may save the same amount by renting a larger unit in a more out-of-the-way location. Indeed, predicting how any single family will alter their consumption is nearly impossible *ex ante*.

The most visible way, at least to the outside observer, in which people change their consumption in response to high housing prices is in their choice of where to live. When housing prices rise in a certain neighborhood, some people will respond by moving to neighborhoods where housing is more affordable. This is, essentially, the process behind neighborhood-level gentrification. Prices rise in a high-demand neighborhood when supply fails to keep up with demand. This price increase leads some people to shift their housing search to more affordable parts of the city—often the invading gentry into one neighborhood were the gentrified of another. Undoubtedly, similar processes play out at city and regional levels—when supply constraints make it difficult to build new housing across some geography and place upward pressure on prices, some people will respond by moving to places where housing is more affordable.

The consequences associated with the way in which supply constraints alter the spatial choices of people are many. For individuals, those who move in response to rising housing prices can lose valuable social networks, access to transportation and employment (Freeman, 2006; K. Newman & Wyly, 2006a). And for communities, by increasing prices, supply constraints may contribute to patterns of suburban sprawl, racial and economic segregation, and economic inequality (Ganong & Shoag, 2017; Lens & Monkkonen, 2016; Moretti, 2013; Pendall, 1999a; Rothwell & Massey, 2010).

If supply constraints affect where people live, might they also affect the type of housing they live in? Of course, all people, even those living in markets where it is easy to build new housing, must make trade-offs between location, expenditure, and unit characteristics. This observation has been central to formal analyses of urban spatial arrangements. In simple versions of the Alonso-Muth-Mills model, for example, people make trade-offs between housing consumption and proximity to the urban core (Alonso, 1964; Mills, 1967; Muth, 1969). Lower housing costs compensate people for living farther out from centers of employment. Because housing is cheaper on the periphery, in these areas people tend to consume more housing than they would if they lived closer to the city center. These models are most useful to understand patterns of land use—with housing density declining with distance from the central city. And they can explain, at least when distilled to a simple conceptual form, the basic trade-offs people make between space, price, and distance from employment.

But of course, when searching for housing people consider more than just a unit's price, size, and location. While unit size is an, if not the most, important consideration for many households, it is but one of a menu of housing attributes that may be important in their housing search. Some people may only consider a potential unit if it has a dishwasher, while for others onsite parking or outdoor space may be must-have amenities. Because these, and countless other, unit attributes may be important for people as they search for housing, the trade-offs a household are substantially more nuanced than the Alonso-Muth-Mills models posit. Indeed, a family who strongly prefers a new unit, or one with a nice-but-not-essential amenity like central AC may in fact trading-off location and price for certain unit attributes, not just size.

How then might supply constraints affect the physical characteristics of housing people occupy? Just as supply constraints, by raising the price of housing, might impact where a family rents or buys, it follows that these changes might also impact what type of housing people occupy. Housing preferences, like all preferences, are to an extent idiosyncratic—after all, one person's trash is another person's treasure. But if most housing attributes increase the price of a unit, supply constraints will push one's preferred bundle of housing attributes slightly farther out of reach. As a result, I expect to find evidence that in expensive, supply-constrained markets people consume less housing (less of all housing attributes) than they would if they lived in markets where housing is plentiful and affordable.

Design and Methods

To examine how supply constraints affect individual housing consumption, I use a variation of the design developed in Glaeser and Luttmer's (1997) study of rent control laws in New York City.[9] They argue that rent controls lead private markets to misallocate housing, with people occupying either larger or smaller units than they would if they lived in cities without such regulations. Because rent control laws discourage moving, some people stay in large apartments when they would otherwise

[9] The same authors also published an updated version of this paper under the same name in 2003 (E. L. Glaeser & Luttmer, 2003). The method in the published paper is different as are the data.

downsize as their family changes. While others, because rent controls cause housing shortages, occupy smaller units than they would in more competitive markets.

To test for misallocation, they use American Housing Survey (AHS) data to examine whether demographic characteristics associated with demand for larger (or smaller) rental units differ statistically between NYC and a control group of markets without rent control laws. Essentially, their design compares the size of units occupied by demographically-similar households across the country. The difference they observe in the unit sizes of NYC households and those in markets without rent controls, they argue, is the misallocation caused by NYC's rent control laws.

I do not test whether supply-constrained markets misallocate housing, but rather whether supply constraints distort patterns of housing consumption. Like Glaeser and Luttmer, I compare consumption patterns in supply-constrained markets and a control group of relatively unconstrained places. If my models show that certain people in supply-constrained markets are less likely to occupy certain types of units, it's not a sign that the market is misallocating this amenity in the pure economic sense; housing in these cities may still be going to people based on their willingness to pay for them. Rather, I interpret these differences as evidence that supply constraints distort the physical characteristics of housing people consume.

I use data from the metropolitan waves of the AHS, a census survey which captures detailed unit- and occupant-characteristics of a representative sample of a metropolitan statistical area's (MSA) housing stock. I use these data to estimate a series of models measuring the associations between various occupant socioeconomic characteristics and the presence or absence of certain housing attributes. I interact each of the socioeconomic predictors with a dichotomous measure of whether the observation is in an expensive, supply-constrained MSA or one where the housing stock is *relatively* affordable and responsive to changes in demand. I interpret differences between the estimated coefficients of the constrained and unconstrained places as evidence of the impact that supply constraints have on patterns of housing consumption.

My outcome variables are dichotomous measures of whether a household occupies a unit with a specific housing attribute. The AHS asks a detailed set of questions on unit attributes, including a set on physical quality. In total, I estimate ten models estimating the impact that supply constraints have on four broad categories of housing attributes—housing problems, occupant-assessments of unit quality, general amenities, and unit crowding. **Table 11** provides a description of each of the housing attributes I test in this analysis.

Table 11: *Dependent Variables*

Variable	Description	Min	Max	Mean
Unit Age	Age of the unit.	1	94	44.0
No External Problems	Unit does not have holes and cracks in the foundation, missing shingles, holes in roof, sagging roof, missing siding or bricks, boarded up windows, or broken windows.	0	1	0.47
Cosmetic Problems	Unit has one of the following problems: holes in the floor, wall cracks wider than a dime, peeling paint, missing shingles, or walls missing bricks.	0	1	0.08
Unit In Adequate Condition	No major housing problems.	0	1	0.94
Rate Unit Quality Poorly	Occupant ranks unit 8 or worse on a 1 to 10 scale.	0	1	0.18
Landlord Quickly Solves Maintenance Problems	Landlord solves minor or major maintenance requests quickly.	0	1	0.65
Occupants-Per-Bedroom	Number of unit occupants per bedroom.	0.1	8.0	0.97
Occupants-Per-Room	Number of unit occupants per room.	0.1	6.0	0.45
Central Air-Conditioning	Unit has central air-conditioning.	0	1	0.57
In-Unit Laundry	Unit has in-unit laundry.	0	1	0.63

I predict these unit attributes based on a series of variables measures the socioeconomic characteristics of the occupant. I follow the work of previous researchers who identify associations between a range of occupant characteristics and the physical attributes of their units, including—age, race, unit location (suburbs versus the central city), income, and educational attainment (Cornwell & Hall, 2017; Glaeser & Luttmer, 1997; Kutty, 1999). I present two sets of models. In the first, I predict the outcome attribute based on the dichotomous measure of whether the observation is in an expensive, supply-constrained MSA and the socioeconomic controls. I next repeat these specifications but interact the constrained dummy with the observation's income-to-AMI ratio and whether the observation is in central city of the MSA. This latter specification allows me to test whether the relationship between living in a constrained MSA and occupying a unit with a certain attribute varies based on household income and location within the MSA. Put more simply, it allows me to test whether the housing distortion caused by living in a constrained MSA is the same for high-income households as it is for those with relatively low-incomes and for those living in the central city as those in the suburbs.

I should be clear that with this design I am not, as Kutty (1999) and others have done in prior research, examining which household demographic characteristics are associated with people occupying housing units with certain amenities or problems, at least not directly. Instead, I am testing whether the association between a household's socioeconomic characteristics and the likelihood they occupy units with certain attributes varies statistically between highly-constrained and relatively unconstrained places.

The reliability of this design hinges on one primary assumption: that relative group preferences for certain housing attributes is uniform across housing markets. For ease of interpretation, I focus primarily on differences in consumption between constrained and unconstrained places based on household income. Thus, I am assuming that if in an unconstrained market higher-income households prefer more of some amenity than those with lower incomes, this relationship must also hold in supply-constrained places. This is not say that certain cities do not attract households with strong or weak preferences for certain housing attributes. Large households who prefer multi-bedroom units may never live in downtown San Francisco, where housing is scarce, expensive, and dense. Instead they may choose to live in a market like Las Vegas, where land and housing are plentiful. But, if there is a positive association between household income and unit size in San Francisco, that relationship must also hold in Las Vegas.

Unfortunately, I am not able to fully control for the possibility that relationship between certain socioeconomic characteristics and a household's preference for certain unit attributes might differ between cities. It could be that in amenity-rich places, for instance, high-income households eat more of their meals in restaurants and thus prefer units with smaller kitchens. While low-income households economize by eating more of their meals at home and thus have stronger preferences for units with well-appointed kitchens. If this were the case, I may falsely attribute differences in housing consumption to supply constraints, when they are in fact due to unobservable differences in preferences for other types of consumption that are substitutes for housing.

However, with the specific set of housing attributes I measure in this paper—especially the presence of housing problems—it is hard to think a plausible explanation for why relative preferences would vary dramatically between MSAs.

While high-income households in constrained markets may be more willing to rent units with certain cosmetic problems than if they lived in an affordable market, they will still be *slightly* less willing than low-income households in the same market. Glaeser and Luttmer (1997) provide several tests for the validity of this assumption and find little evidence that it does not hold.

Assigning MSA to Constrained and Unconstrained Groups

My analysis compares the housing outcomes of people who receive the 'treatment' of living in a highly supply-constrained MSAs with a 'control' group of people who reside in relatively unconstrained places. The effect of the living in a constrained market is the difference in the association between membership in various socioeconomic groups and the likelihood that the household in question occupies a unit with a given attribute.

The persuasiveness of my design ultimately hinges on how I assign, and justify the assignment of, MSAs to the constrained and unconstrained groups. Unlike in Glaeser and Luttmer's study where the treatment and control categories are mutually-exclusive and objectively verifiable—either a city has a rent control law, or it doesn't—my determination of which MSAs to assign to the supply-constrained group and which to the unconstrained group somewhat subjective.

Constraints which affect the development of new housing, especially when measured at the MSA-level, do not exist in absolutes. Even in the most supply-constrained housing markets developers can build some new housing and even relatively unconstrained places still have issues with land availability, regulations, and community opposition to new housing which constrain new development. Further, constraints on new development may vary dramatically within a given MSA. Some municipalities may tightly regulate new development, while others within the same MSA may encourage, or at least be more permissive towards, new housing. I can control for some of these empirical challenges in my design, but others, especially within MSA-variation in supply constraints, are more difficult and thus I must take into consideration when interpreting my results.

I assign MSAs to the constrained group based primarily on the empirical findings of previous researchers who study the presence and impact of housing supply constraints. In my search of the housing and planning literatures, analysts consistently cite the impact that supply constraints have on the housing markets of a few key cities. Specifically, analysts have shown that in New York (E. L. Glaeser, Gyourko, & Saks, 2005b), San Francisco (Kok et al., 2014; Saiz, 2010a), Boston (E. L. Glaeser & Ward, 2009; Schuetz, 2009), Los Angeles (Kahn, 2011), and Washington DC (D. Hyra, 2015) high demand for housing coupled with limits on new development have increased competition for the existing housing stock and raised prices. As a first cut, I assign all observations located in these five MSAs to the constrained group. I also test the sensitivity of my analysis by widening my pool of highly supply-constrained MSAs to include other MSAs that appear constrained based on the results of my descriptive analysis, but that have received less scholarly attention, including—Seattle, San Diego, San Jose, and Denver. Including the larger set of constrained cities has little impact on my models.

I assign most, but not all, of the remaining places in my sample to the unconstrained group. I omit MSAs for one of four reasons. First, I do not include the set of MSAs which I include in the expanded constrained group—Seattle, San Diego, San Jose, and Denver. I also exclude a handful of MSAs that are located near (and arguable within the same larger housing market of) one of the constrained MSAs—Oakland, Anaheim, and Riverside. I exclude a set of declining MSAs, largely in the post-industrial rust-belt—Cleveland, Detroit, Buffalo, Cincinnati, and New Orleans. In these places, while housing may be plentiful and new development relatively unconstrained, I expect that larger changes in the economies and populations (and in the case of New Orleans, the aftermath of Hurricane Katrina) of these places make comparing them to the housing problems in growing, high-demand places difficult.

Figure 4 graphically shows several descriptive statistics for the MSAs which the Census included in the 2011 and 2013 waves of the AHS. The red bars denote the MSAs which I include in the more restrictive constrained group, the green bars are those in the unconstrained group, and the grey bars MSAs I excluded from my analysis (or included in the expanded constrained groups). As expected, these MSAs have much higher average housing costs, as measured by average rents, and higher average incomes than the constrained group. The constrained MSAs also have lower-vacancy rates, both across all units in the markets and among renter-occupied units.

In Panels E and F of **Figure 4**, I borrow data from two studies which provide direct measures of regulations which affect new housing development. In Panel E, I show the average Wharton Residential Land Use Regulation Index (WRLURI) score for the MSAs in my sample. Gyourko et. al. (2008) created the WRLURI based on a nation-wide survey of land use regulations completed by local planners and local government officials. The researchers used factor analysis techniques to create the normalized WRLURI, with the larger positive scores indicating more highly regulated markets. Panel F shows the ratio of average housing prices to average production cost as estimated in Glaeser and Gyourko (Glaeser & Gyourko, 2018). Housing prices should trend towards the cost of new construction when producers can build housing to respond to demand diverge where supply constraints make it difficult to build. As expected, by these measures my constrained MSAs appear to have more restrictive land use regulations and much higher housing prices relative to building costs.

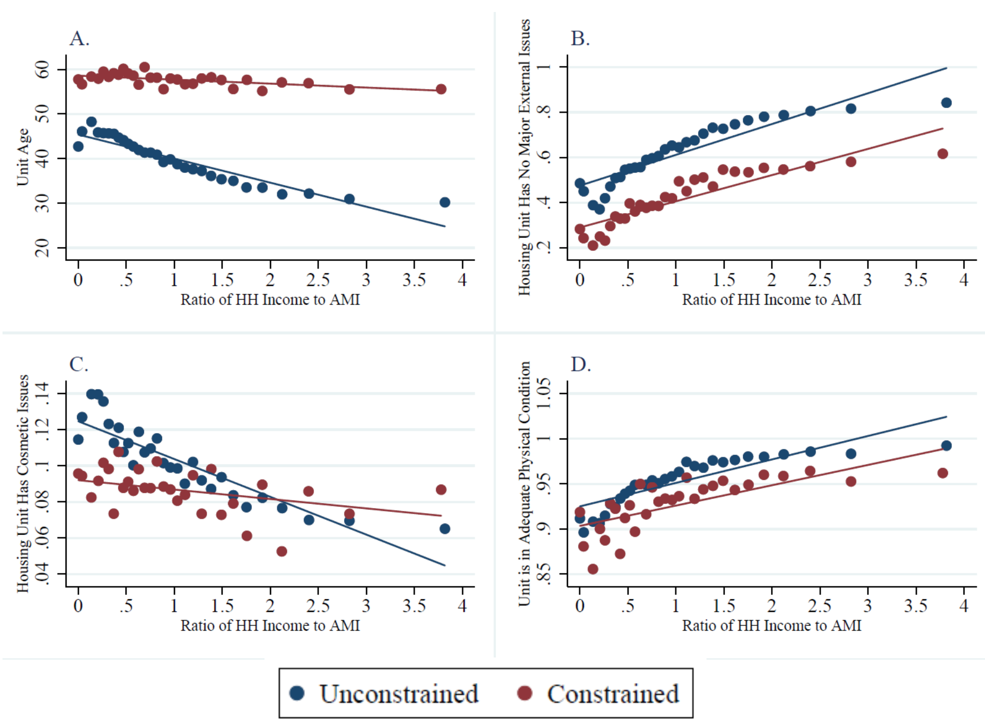
Figure 4: *Descriptive Stats*


D.
Las Vegas
Tucson
Indianapolis
Jacksonville
Tampa
Birmingham
Columbus
Memphis
Cincinnati
Atlanta
Baltimore
Oklahoma City
Phoenix
Houston
Hartford
Chicago
Orlando
Cleveland
Miami-Hialeah
Richmond
Kansas City
Rochester
San Antonio
Nashville
Saint Louis
Detroit
Dallas
Buffalo
Charlotte
Austin
Philadelphia
Fort Worth-Arlington
Louisville
Pittsburgh
Milwaukee
Denver
Sacramento
Seattle
Washington DC
Riverside
Oakland
Minneapolis-Saint Paul
NYC
Boston
Providence
Los Angeles
San Diego
Anaheim
San Jose
San Francisco
0
.05
.1
.15
.2
Rental Vacancy Rate
Source: AHS, Author's Calculations
E.
Kansas City
Indianapolis
Saint Louis
Las Vegas
Cincinnati
Louisville
Nashville
Charlotte
Houston
Richmond
Oklahoma City
Austin
Fort Worth-Arlington
Birmingham
Dallas
Buffalo
Tampa
San Antonio
Cleveland
Rochester
Jacksonville
Chicago
Atlanta
Detroit
Pittsburgh
San Jose
Columbus
Orlando
Minneapolis-Saint Paul
San Diego
Washington DC
Milwaukee
Hartford
Los Angeles
Sacramento
Riverside
Oakland
Phoenix
NYC
San Francisco
Denver
Seattle
Miami-Hialeah
Philadelphia
Memphis
Tucson
Baltimore
Boston
Providence
-1
-.5
0
.5
1
1.5
2
Wharton Index Score
Source: Gyourko et. al. (2008)
F.
Pittsburgh
Indianapolis
Las Vegas
Rochester
Houston
Detroit
Memphis
Kansas City
Cleveland
San Antonio
Cincinnati
Birmingham
Tampa
Orlando
Dallas
Fort Worth-Arlington
Milwaukee
Jacksonville
Columbus
Atlanta
Oklahoma City
Nashville
Tucson
Providence
Minneapolis-Saint Paul
Chicago
Miami-Hialeah
Phoenix
Philadelphia
Riverside
Sacramento
Austin
Baltimore
Seattle
NYC
Denver
Boston
Washington DC
San Diego
Los Angeles
San Francisco
0
.5
1
1.5
2
2.5
3
Housing Price to Minimum Production Price Ratio
Source: Glaeser & Gyourko (2018)
Excluded
Constrained
Unconstrained

Results: Supply constraints and Unit Quality

In **Figure 5** I present four binned scatter plots showing the relationship between the ratio of an observation's household income to the family size-adjusted AMI to one of the four housing outcomes broadly related to basic physical quality (age, external problems, cosmetic problems, unit adequacy). I use the binned scatter plots over traditional scatter plots, as they make it easier to see trends in dataset with many observations. To construct these plots, I divide my observations in 30 equal bins (30-quantiles) based on the observation's income-to-AMI ratio. I then plot the mean of the housing attribute outcome against the mean of the income-to-AMI ratio within each bin. I do this computation twice—once for my constrained group and once for the unconstrained MSAs—and include a linear fit line to help visualize trends in the data.

Figure 5: *Bin-Scatters, Age and Condition*



Panel A shows the relationship between the income-to-AMI ratio and housing unit age. Across all the income-to-AMI bins, households living in constrained MSAs occupy older housing on average than those living in the unconstrained group. Further, while there appears to be a linear and negative relationship with income and unit age in unconstrained MSAs, that relationship is much weaker in the constrained group. Based on this binary analysis, there appears to be essentially no relationship between occupant income and structure income in expensive, supply-constrained markets.

In Panel B, I show a similar difference in the relationship between income-to-AMI and the likelihood an observation's unit as no major exterior problems. Across all income bins, observations in the unconstrained MSAs are, on average, more likely to occupy units without exterior problems than those in supply-constrained housing markets. While there appears to be a weak relationship between income-to-AMI ratio the probability a unit has a cosmetic issue (Panel C), there does not appear to be much difference based on whether the unit is in a constrained or unconstrained MSA.

Finally, in Panel D I plot binned income-to-AMI against whether the unit is in adequate physical condition. While the majority housing units in supply-constrained and the unconstrained MSAs are in adequate condition, there remains a positive association between income-to-AMI ratios and unit adequacy. And, in most income bins, observations in supply-constrained MSAs are slightly less likely to be in adequate physical condition than those in the unconstrained group.

Table 12: *Regression Results*

	(1) Unit Age	(2) No External Housing Problems?	(3) In Adequate Condition?	(4) Cosmetic Problem?	(5) Central AC?	(6) In-Unit Laundry?	(7) Rates Unit Quality Poorly (<8 on 1-10 Scale)?	(8) Landlord Quickly Solves Maintenance Problems ?
Model Type:	*OLS*	*Logit*	*Logit*	*Logit*	*Logit*	*Logit*	*Logit*	*Logit*
Constrained MSA?	6.282***	-0.193*	0.078	-0.286*	-0.523***	-0.682***	-0.168*	0.469***
	(0.688)	(0.078)	(0.174)	(0.122)	(0.135)	(0.112)	(0.079)	(0.135)
Income-To-AMI Ratio	-1.337***	0.135***	0.251***	-0.161***	0.224***	0.291***	-0.132***	-0.013
	(0.090)	(0.011)	(0.036)	(0.018)	(0.016)	(0.025)	(0.012)	(0.038)
Located in Central City?	12.878***	-0.796***	-0.348***	0.252***	-0.662***	-0.720***	0.175***	0.090***
	(0.237)	(0.024)	(0.046)	(0.034)	(0.031)	(0.031)	(0.024)	(0.025)
3 or More Adults in Unit?	1.357***	0.140***	-0.038	0.139***	-0.095*	0.422***	0.028	-0.035
	(0.294)	(0.033)	(0.061)	(0.042)	(0.038)	(0.048)	(0.030)	(0.054)
Any Children?	-2.822***	0.618***	0.205***	0.163***	0.336***	0.991***	0.036	0.052
	(0.278)	(0.029)	(0.060)	(0.041)	(0.037)	(0.043)	(0.028)	(0.049)
Single Parent?	3.342***	-0.294***	-0.345***	0.231***	-0.320***	-0.264***	0.188***	-0.042
	(0.334)	(0.038)	(0.070)	(0.047)	(0.044)	(0.053)	(0.034)	(0.057)
HH Head Age	0.071***	0.004***	0.005***	-0.008***	-0.001	0.003**	-0.015***	0.009***
	(0.007)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HS Grad?	0.483	0.069*	0.113*	-0.070	-0.019	-0.055	-0.019	-0.011
	(0.248)	(0.028)	(0.051)	(0.039)	(0.033)	(0.036)	(0.026)	(0.043)
College Grad?	-1.864***	-0.002	0.269***	-0.121**	0.499***	0.169***	-0.152***	0.06
	(0.241)	(0.025)	(0.054)	(0.037)	(0.033)	(0.036)	(0.026)	(0.046)
HH Head Black?	-0.399	-0.378***	-0.234***	0.219***	-0.447***	-0.383***	0.067*	-0.114*
	(0.307)	(0.033)	(0.057)	(0.045)	(0.039)	(0.040)	(0.031)	(0.048)
HH Head Asian?	-4.952***	-0.291***	0.059	-0.344***	0.061	-0.459***	0.231***	-0.096
	(0.469)	(0.048)	(0.098)	(0.083)	(0.056)	(0.062)	(0.046)	(0.076)
HH Head Latinx?	1.312***	-0.312***	-0.139*	-0.007	-0.530***	-0.590***	-0.146***	-0.133**
	(0.305)	(0.032)	(0.061)	(0.047)	(0.042)	(0.042)	(0.032)	(0.049)
Renter?	0.304	-1.848***	-0.657***	-0.210***	-0.652***	-2.552***	0.612***	--
	(0.244)	(0.024)	(0.052)	(0.037)	(0.032)	(0.038)	(0.024)	
Subsidized Rent?	-7.732***	-0.460***	0.046	0.029	0.264***	-0.313***	-0.106*	0.247***
	(0.560)	(0.068)	(0.080)	(0.084)	(0.060)	(0.061)	(0.051)	(0.064)
Constant	32.615***	0.938***	2.872***	-1.741***	3.001***	3.134***	-0.350***	0.486***
	(0.704)	(0.079)	(0.173)	(0.120)	(0.135)	(0.121)	(0.080)	(0.126)
MSA Fixed Effects?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
N	115,193	115,193	115,193	115,193	115,193	115,193	115,193	42,570
adj. R-sq	0.275	--	--	--	--	--	--	--

Standard errors in parentheses; * p<.05, ** p<.01, *** p<.001

Note: Data from the 2011 and 2013 metro-samples of the American Housing Survey. All the regressions are weighted using the survey weights provided in the AHS. Excluding the weights has little impact on the regressions. For landlord responsiveness regressions, I limit the sample to renter-occupied units and thus exlude the unit tenure control.

Table 13: *Regression Results*

	(1) Unit Age	(2) No External Housing Problems?	(3) In Adequate Condition?	(4) Cosmetic Problem?	(5) Central AC?	(6) In-Unit Laundry?	(7) Rates Unit Quality Poorly (<8 on 1-10 Scale)?	(8) Landlord Quickly Solves Maintenance Problems ?
Model Type:	*OLS*	*Logit*	*Logit*	*Logit*	*Logit*	*Logit*	*Logit*	*Logit*
Constrained MSA?	4.920***	0.141	0.396*	-0.468***	-0.263	-0.131	-0.264**	0.486***
	(0.724)	(0.083)	(0.186)	(0.130)	(0.138)	(0.118)	(0.083)	(0.141)
Income-To-AMI Ratio	-1.931***	0.209***	0.468***	-0.200***	0.464***	0.761***	-0.175***	0.110***
	(0.093)	(0.016)	(0.050)	(0.021)	(0.026)	(0.038)	(0.015)	(0.030)
Constrained * Income-To-AMI Ratio	1.635***	-0.150***	-0.371***	0.101**	-0.332***	-0.648***	0.103***	(0.037)
	(0.190)	(0.021)	(0.059)	(0.034)	(0.029)	(0.043)	(0.022)	-0.044
Located in Central City?	13.790***	-0.515***	-0.299***	0.160***	-0.629***	-0.566***	0.189***	-0.02
	(0.248)	(0.026)	(0.051)	(0.037)	(0.035)	(0.035)	(0.025)	(0.042)
Constrained * Located in Central City?	-3.052***	-0.902***	-0.105	0.330***	-0.039	-0.339***	-0.052	0.026
	(0.564)	(0.058)	(0.099)	(0.085)	(0.063)	(0.065)	(0.055)	-0.087
3 or More Adults in Unit?	1.398***	0.136***	-0.045	0.141***	-0.113**	0.392***	0.030	-0.036
	(0.294)	(0.033)	(0.061)	(0.042)	(0.039)	(0.048)	(0.030)	(0.054)
Any Children?	-2.801***	0.622***	0.196**	0.166***	0.329***	0.997***	0.038	0.051
	(0.277)	(0.029)	(0.060)	(0.041)	(0.037)	(0.043)	(0.028)	-0.049
Single Parent?	3.311***	-0.283***	-0.326***	0.225***	-0.297***	-0.235***	0.183***	-0.041
	(0.333)	(0.038)	(0.071)	(0.047)	(0.043)	(0.052)	(0.034)	(0.057)
HH Head Age	0.072***	0.004***	0.005***	-0.008***	-0.001	0.003***	-0.015***	0.009***
	(0.007)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	-0.001
HS Grad?	0.478	0.072**	0.116*	-0.071	-0.014	-0.052	-0.020	-0.011
	(0.247)	(0.028)	(0.051)	(0.039)	(0.033)	(0.035)	(0.026)	(0.043)
College Grad?	-1.813***	-0.014	0.259***	-0.119**	0.473***	0.129***	-0.148***	0.059
	(0.241)	(0.026)	(0.055)	(0.038)	(0.033)	(0.037)	(0.026)	-0.046
HH Head Black?	-0.521	-0.398***	-0.226***	0.226***	-0.431***	-0.371***	0.063*	-0.113*
	(0.307)	(0.033)	(0.057)	(0.044)	(0.039)	(0.041)	(0.031)	(0.048)
HH Head Asian?	-4.933***	-0.293***	0.063	-0.346***	0.066	-0.454***	0.230***	(0.096)
	(0.468)	(0.048)	(0.098)	(0.083)	(0.056)	(0.062)	(0.046)	-0.076
HH Head Latinx?	1.356***	-0.334***	-0.148*	0.001	-0.535***	-0.600***	-0.142***	-0.133**
	(0.304)	(0.033)	(0.061)	(0.047)	(0.041)	(0.042)	(0.032)	(0.049)
Renter?	0.348	-1.834***	-0.634***	-0.219***	-0.624***	-2.527***	0.609***	--
	(0.243)	(0.024)	(0.052)	(0.037)	(0.032)	(0.038)	(0.024)	
Subsidized Rent?	-7.381***	-0.455***	0.032	0.033	0.272***	-0.254***	-0.093	0.247***
	(0.556)	(0.067)	(0.079)	(0.084)	(0.058)	(0.060)	(0.051)	(0.064)
Constant	33.042***	0.819***	2.702***	-1.690***	2.799***	2.769***	-0.313***	0.475***
	(0.701)	(0.080)	(0.175)	(0.120)	(0.137)	(0.122)	(0.080)	-0.127
MSA Fixed Effects?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	115,193	115,193	115,193	115,193	115,193	115,193	115,193	42,570
adj. R-sq	0.277	--	--	--	--	--	--	--

Standard errors in parentheses; * p<.05, ** p<.01, *** p<.001

Note: Data from the 2011 and 2013 metro-samples of the American Housing Survey. All the regressions are weighted using the survey weights provided in the AHS. Excluding the weights has little impact on the regressions. For landlord responsiveness regressions, I limit the sample to renter-occupied units and thus exlude the unit tenure control.

In **Table 12**, I present the full naïve regression results for eight of the housing attributes I test in this paper. Depending on the variable, I estimate my models using either Logit or OLS regression techniques. In each model, I control for a series of demographic occupant characteristics, including: income family structure, education, race. I also include controls for whether the unit is in the central city of the MSA, whether the occupant rent or owns their unit, and whether they receive a subsidy for their rent. In all the models, I control for variation in housing attributes at the MSA-level with MSA fixed effects. The models in **Table 13** mirror those in **Error! R eference source not found.**, but I interact the dichotomous measure of whether the unit is in one of the five expensive, supply-constrained MSAs with the occupant's income-to-AMI ratio and whether it is in the central city of its MSA. For the interacted models, I estimate the average predicted probabilities (or linear predictions for the OLS models) that a housing unit has some attribute for households with incomes ranging from 0 to 5 times their MSA's AMI based on whether the observation is in a constrained or unconstrained MSAs.[10] I also estimate the marginal effects of living in a constrained city based on the whether the observation is in the central city, or suburbs of the MSA.

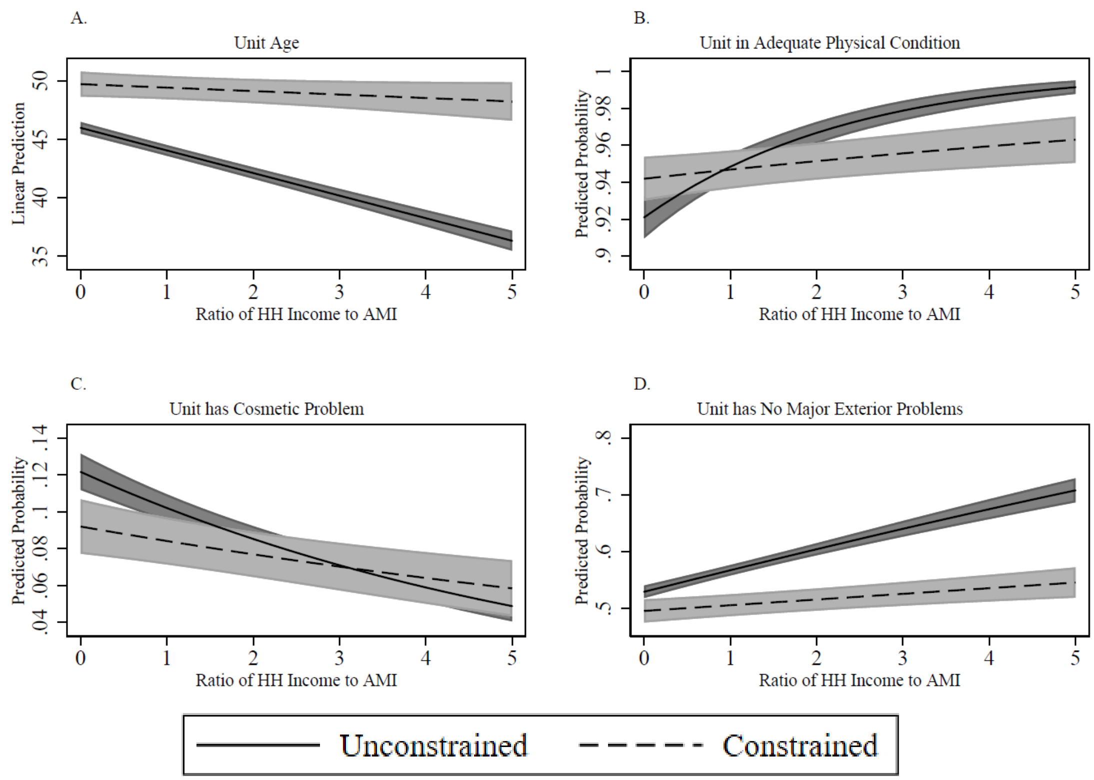
As the results in **Table 13** show, I find a positive and statistically significant association between location in a constrained MSA and the age of a family's housing

[10] I rely primarily on a margins analysis for two reasons. First, the predicted probabilities are easier to understand from a substantive policy perspective, than are the regression coefficients. Second, interpreting interaction effects in non-linear logit models is challenging. As Ai and Norton (2003) and Buis (2010) point out, in non-linear models, regression coefficients of interaction terms do not equal the marginal effect of the interaction term. I thus use margins analysis to estimate the marginal coefficients in these models.

unit. My models also suggest a negative association between a unit's location in a constrained MSA and the likelihood it does not have a major exterior problem. I find no association between location in a constrained MSA and unit adequacy and a weak negative, but statistically significant association with the likelihood a unit has a cosmetic problem.

Figure 6 shows the results of the margins analysis for my four physical condition outcome variables. The results generally confirm what I present in the binary analysis and in the naïve regressions. Panel A shows that not only do households of all income levels live in newer units in the unconstrained MSAs, but the relationship between income and unit-age is stronger in unconstrained MSAs. This model suggests that for households earning five times the AMI, the average family in a supply-constrained market lives in a house built in approximately 1965; while the average family in a relatively affordable market lives in a unit built in approximately 1976.

Figure 6: *Predictive Margins*



I find some, although admittedly mixed, evidence that people in supply-constrained places not only live in older units, but also units with more physical problems. Panel B shows the predicted probability of occupying a unit in adequate physical condition. My model suggests that there is little difference in the predicted probability that a family's unit is in adequate physical condition when a household earns less than double the AMI, and a slightly lower probability of unit adequacy in supply-constrained MSAs for people earning over two times the AMI. My models suggest that for household earning under the AMI, those in constrained MSAs are slightly less likely than those in the unconstrained group to occupy units with cosmetic problems, but this difference disappears for higher income households. Finally, my model suggests that living in a constrained MSA has little impact on the probability that households earning under the AMI will live in units without exterior problems. But the models do suggest that the probability that a household lives in a unit without an exterior problem based on whether they live in a constrained or unconstrained MSA diverges as incomes rise. People in supply-constrained MSAs who earn twice the AMI have a 52% predicted probability of living in a unit without an exterior problem, while this probability is 60% for the households at the same relative income level in a unconstrained MSA.

Figure 7: *City v. Suburban Units*

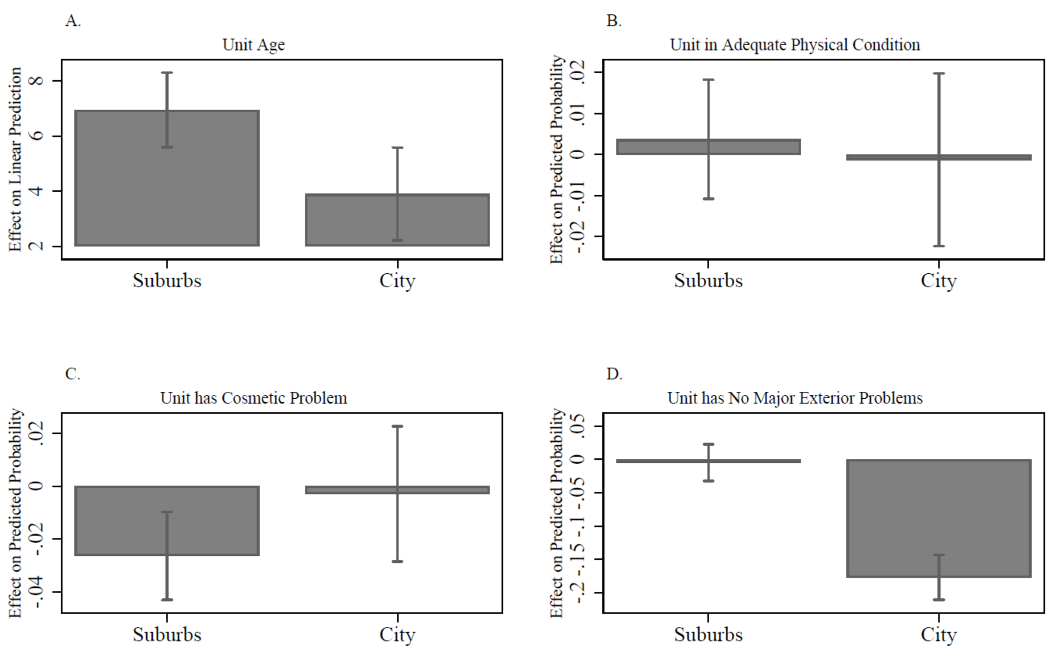


Figure 7 shows the estimated marginal effects of living in a constrained MSA based on the whether the unit is in the central city or a suburb. My models suggest that an observation in its MSA matters, but how location matters varies based on the outcome in question. For example, Panel A shows that the marginal effect of location in a constrained MSA on unit age is larger if the observation is in the suburb than in

the central city. As Panel D shows, however, the marginal effect of living in a constrained MSA on the probability of living in a unit without a major exterior problem is much larger for central city units than those in the suburbs. My models suggest that central city units in constrained MSAs are 20 percentage points less likely to be without major exterior problems than those in the central cities of unconstrained MSAs.

Supply constraints and Assessments of Unit Quality and Maintenance

While I find some evidence that people in supply-constrained housing markets live in older units and those with certain physical problems, I find little evidence that these people are more likely to subjectively rate the condition of their unit poorly or respond that their landlord quickly solves maintenance issues as they arise.

Figure 8: *Bin-Scatter Self-Assessment and Maintenance*

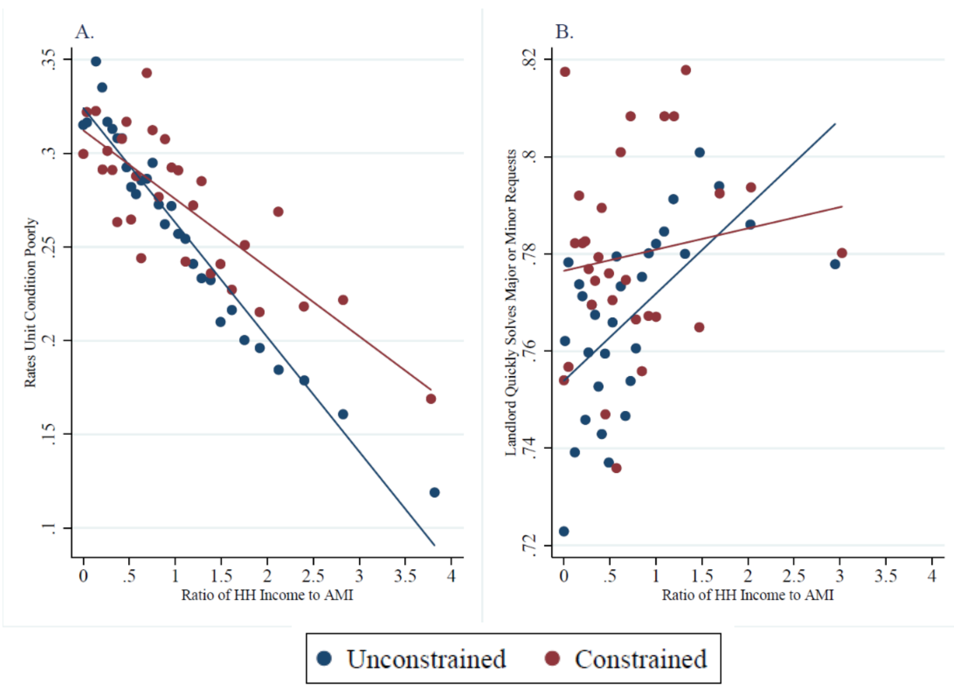


Figure 8 shows binned scatter plots of the relationship between an

observation’s income-to-AMI ratio and two variables—one measuring whether respondents rate the quality of their unit less than 8 on a scale of 1 to 10 and the other whether they reply that their landlord quickly solves major or minor problems. While there is a clear relationship between binned income and respondent assessments of unit conditions or maintenance, neither plot shows a clear difference in this association based on whether the respondent lives in a constrained and unconstrained MSA.

Columns 7 through 12 of **Table 12** and **Table 13** show the results of logit regressions predicting whether a respondent rates the overall quality of their unit poorly and whether they respond that their landlord quickly solves maintenance requests. In both the naïve and interacted models, the coefficient on the constrained dummy is negatively associated with an observation rating their unit poorly and positively associated with responding that their landlord quickly solves maintenance requests. Both coefficients are statistically significant. In other words, I find the opposite association than I expected between living in a constrained MSA and these measures of self-assessed unit quality and maintenance satisfaction.

Figure 9: Predicted Probabilities, Self-Assessments

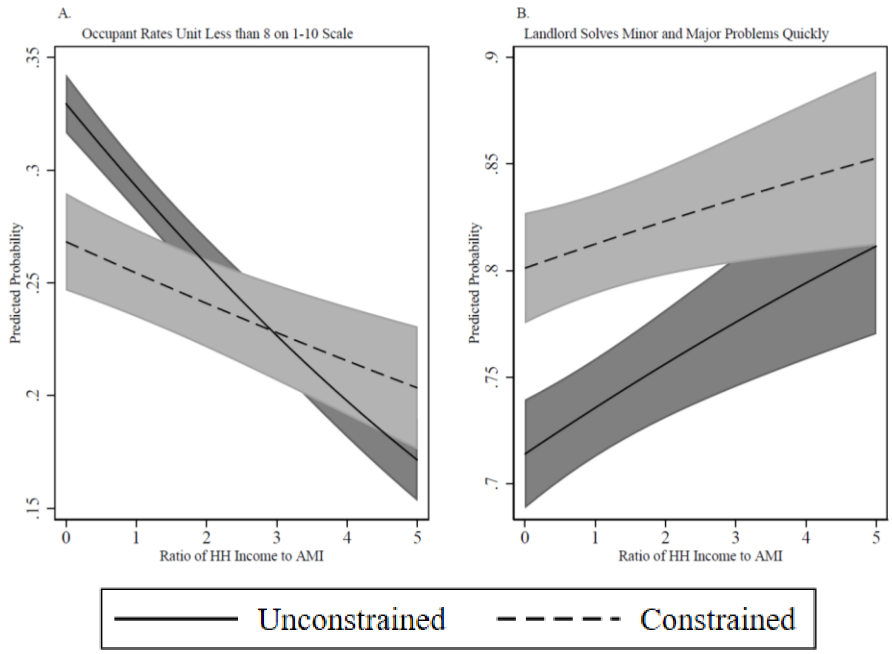


Figure 9 shows the plotted average predicted probabilities based on the observation's income-to-AMI ratio and whether they live in a constrained or unconstrained MSA. In the self-assessments of unit quality model, the average household earning less than the AMI in relatively unconstrained metros is slightly *more* likely to rate their unit poorly than those living supply-constrained MSAs. But the models suggest that differences based on market characteristics disappear as household incomes rise.

I find an analogous result in the models where the dependent variables are respondent assessments of their landlord's responsiveness. My models suggest that holding all other variables at their means, the average renter with an income at the AMI has a 72% probability of responding that their landlord solves minor or major maintenance requests quickly if they live in a unconstrained MSA and an over 80%

probability if they live in one of the constrained metros. However, like with the subject assessment of unit quality, these differences are only statistically significant for households with incomes near the AMI; my models suggest little difference between higher-income households living in constrained and unconstrained places.

Why might there exist differences in objective measures of the physical quality of housing units, but not in subjective assessments of unit quality or maintenance? Although subjective assessments of quality and maintenance are related, it is worthwhile to consider them separately. With assessments of unit quality, it may be that one evaluates their unit based on comparisons with others in their market, rather than consumers across the country. As Frank (1997) has argued, the utility we derive from consuming a good is not bestowed by our biology, but rather determined subjectively, based in part on relative comparisons to the utility of our peers.

People may thus base their evaluation of their unit by comparing their housing situation with the conditions of other people in their market. And if supply constraints affect the housing consumption of everyone in a market similarly, then even though a family's house may be in objectively worse physical condition than those of their peers across the country, it may be no worse than the units of their peers across the street. If this is the case, I would expect subjective measures of unit quality to vary little across MSAs even if there are objective differences in unit characteristics.

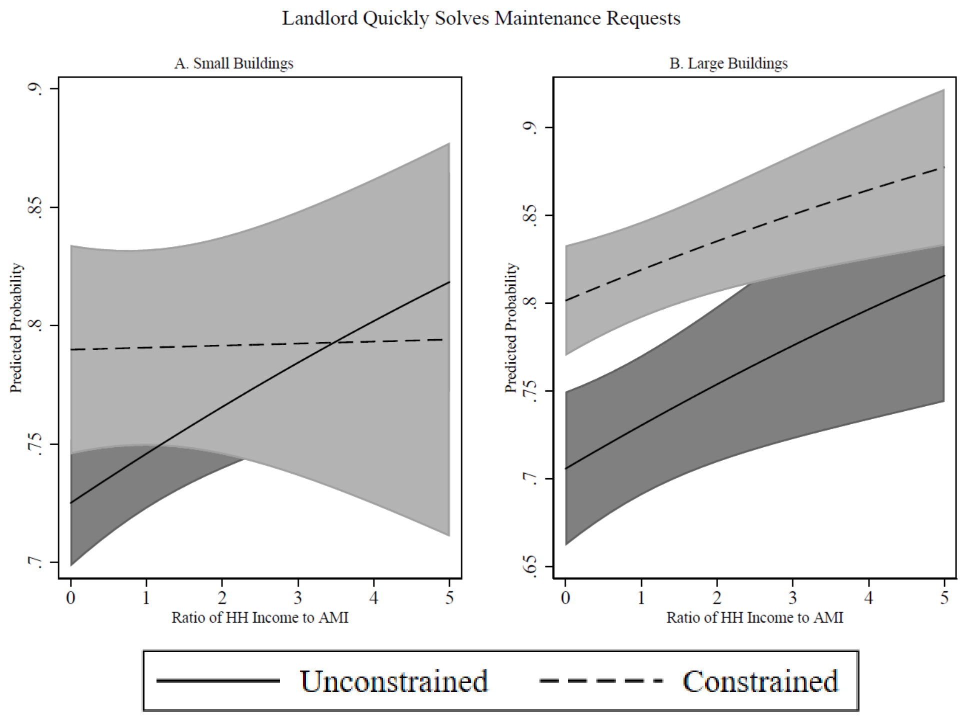
The importance of frames of reference may explain why I find little difference in subjective assessments of unit quality but is less useful in understanding why my models show that renters in supply-constrained markets are more likely to be satisfied with the maintenance of their unit. Unlike with self-assessments of quality, it is unlikely that a family will base their assessment of whether their landlord is responsive to maintenance requests based on the performance of the landlords of their neighbors. A landlord either fixes a problem quickly or they don't; they don't fix a problem reasonably quickly compared to the standard in a particular housing market.

How, then, are we to account for this difference? Just because a landlord is responsive to maintenance requests does not necessarily mean that they are better maintaining their properties. Tenants generally only contact their landlord when something in their unit breaks—for example, to remedy a leaky faucet, blown fuse, or broken appliance. They may be less likely to seek redress for more general quality problems, like an outdated circuit breaker. If this is the case, we may expect that landlords in constrained places will be more responsive to maintenance requests, since they have more problems to respond to.

Relatedly, it could be that in constrained markets landlords are more likely to hire property managers to handle day-to-day maintenance requests. Again, this does not necessarily imply that property owners are investing in the overall physical quality of their properties. It may, however, indicate that they are more responsive to smaller problems when they arise. Perhaps hiring a property manager to fix leaks in perpetuity is less expensive than a full overhaul of a building's plumbing system.

Unfortunately, with the questions in the AHS I am unable to directly test whether there is a difference in the prevalence of property managers in supply-constrained cities. I do, however, find that in supply-constrained markets, renters are more likely to live in a building with six or more units than those in unconstrained markets. To wit: around 60% of renters in constrained MSAs live in these large developments, while only 45% of those in the unconstrained group do.

Figure 10: *Predicted Probabilities by Building Size*



As a further test, I reran the maintenance model broken out by renters living in buildings with either one to five units and those living in buildings with six or more. I present the full regression results in **Appendix 5** and the results of the margins analysis in **Figure 10**. As **Figure 10** shows, my models suggest that the difference in landlord responsiveness I observe in the full model between constrained and unconstrained MSAs is due primarily to differences in the responses of people living in buildings with six or more units. I can only speculate with these data as to why this is the case. But possibly in constrained MSAs property managers benefit from economies of scale that allow them to respond more quickly to tenant concerns.

Ultimately, I am without a good, or at least an empirically-backed, explanation of why my models show that respondents in constrained places are less likely to assess the quality of their unit and the performance of their landlord highly. These results are even more perplexing as they cut against both the remainder of the findings in my present analysis and my *a priori* hypotheses. They thus present two interesting threads for future research projects—one which studies how people assess the quality of their units and a second which has the goal of improving our understanding of how rental market dynamics affect landlord behavior.

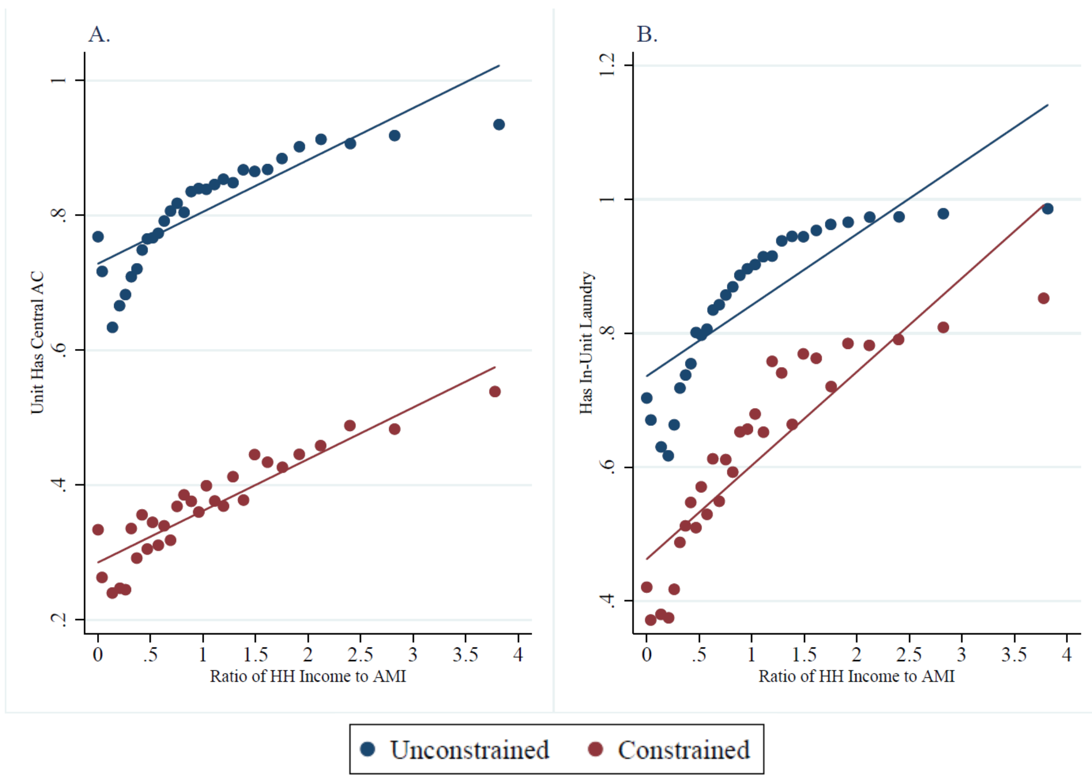
Supply constraints and unit amenities

In the models I have presented thus far, I have primarily examined whether market housing conditions affect the likelihood that people will occupy units with various housing problems. But of course, we assess the quality of a unit on more than just whether certain problems are present. Indeed, if a family is very sensitive to the physical condition of a unit, they may rather move out of a city before they rent a physically inadequate house. But, there are likely a host of other nice-to-have amenities that even the most quality-sensitive household would be willing to sacrifice when searching for housing in a tight market. I test the association that living in a supply-constrained market has on two such housing amenities—whether the unit has central air conditioning and in-unit laundry facilities.

Columns 5 and 6 of **Table 13** show the regression results for my naïve models predicting the likelihood an observation has these two amenities. I find that in expensive, supply-constrained MSAs, units are substantially and statistically less likely to have both central air-conditioning and in-unit laundry facilities.

Figure 11 shows the binned scatter plots of the relationship between a household's income-to-AMI ratio and whether the live in a house with either central air-conditioning or laundry facilities. As expected, there is a strong, positive association between income and occupying a unit with either a central air-conditioning or in-unit laundry. And at all income levels, people in supply-constrained MSAs are less likely to occupy units with housing these two amenities than are people with similar incomes in an unconstrained unconstrained MSA.

Figure 11: Bin-Scatters, Unit Amenities



These binary associations hold in my regression analysis. Figure 12 shows the plotted predicted average probabilities that an observation occupies a house with either central air-conditioning or in-unit laundry facilities. The models predict that an average household living in a constrained MSA earning the AMI is five percentage points less likely to occupy a unit with central air-conditioning and nearly ten percentage points less likely to have an in-unit washing machine.

Figure 12: Predictive Margins, Unit Amenities

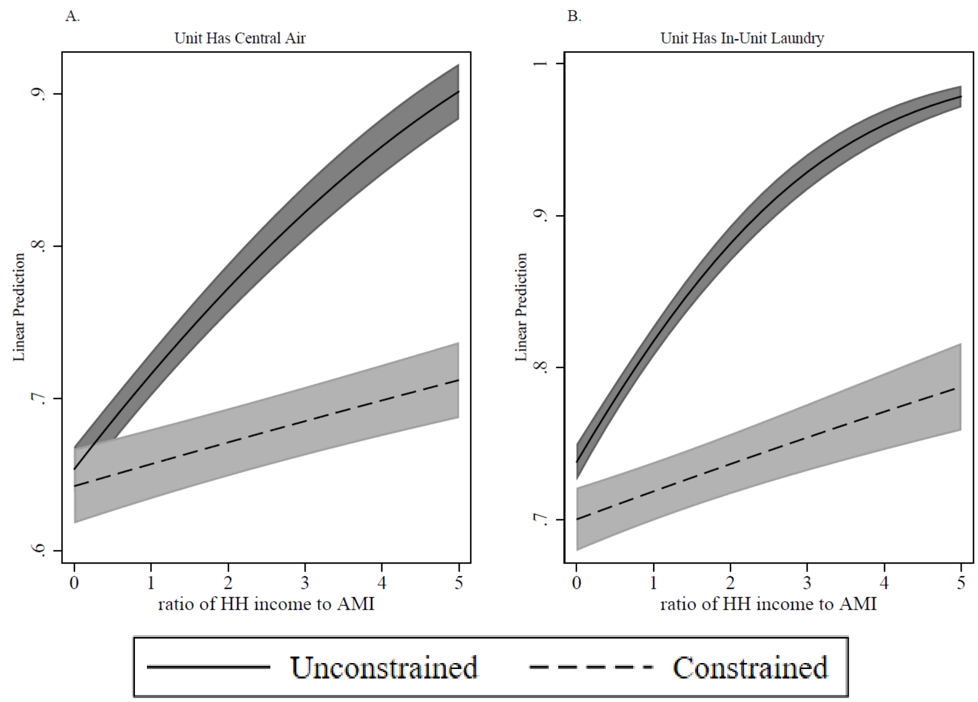
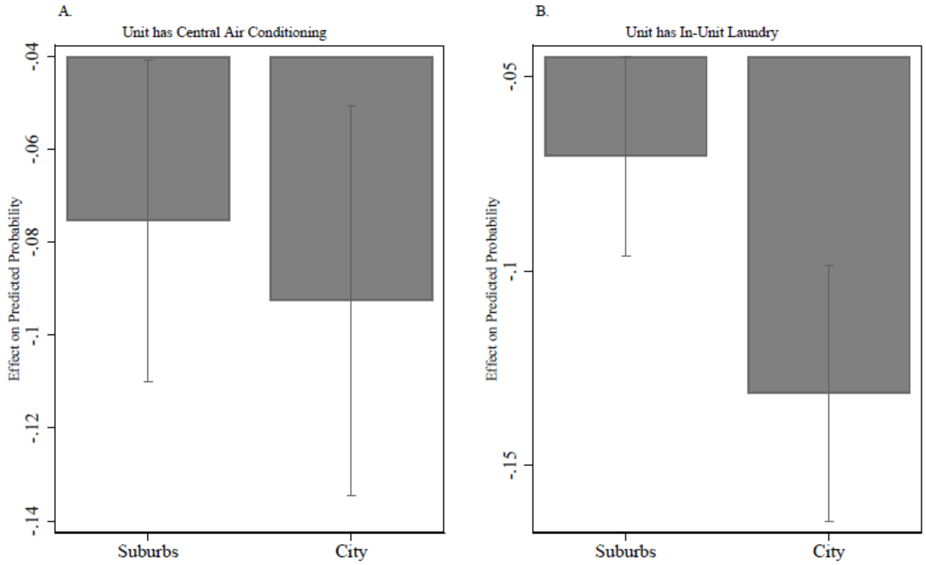


Figure 13 shows the estimated central city and suburban marginal effects of living in a constrained MSA on the probability an observation has either central AC or in-unit laundry. I find no statistically significant difference between the marginal effect of constrained based on location within the MSA on central AC. My models do suggest, however, that the marginal effect of living in a constrained MSA on the probability an observation has in-unit laundry facilities is larger for central city units than for those in the suburbs. Living in the central city of a constrained MSA lowers the predicted probability of having in-unit laundry by 13 percentage points, compared to only 6 percentage points for suburban observations.

Figure 13: City v. Suburbs, Unit Amenities



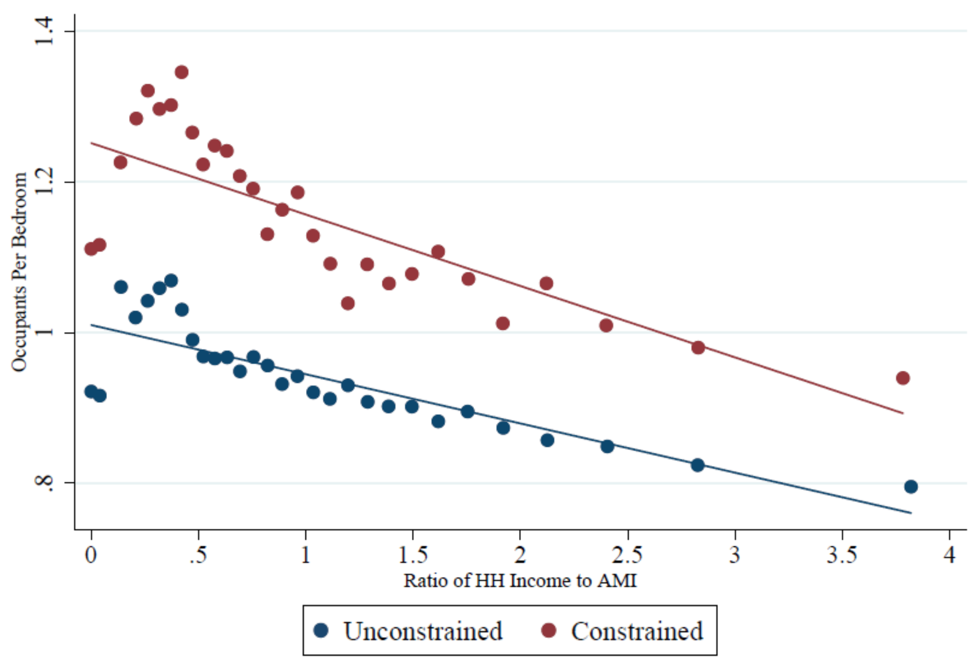
Supply constraints and unit crowding

Finally, I test whether people living in expensive, supply-constrained MSAs change their housing consumption by crowding into smaller units. In these models, my outcome variable is the ratio of occupants in a unit to the total number of bedrooms. Since the dependent variable in these models is a continuous rather than dichotomous measure, I estimate this model using an OLS specification.

Figure 14 shows the binned scatter plots for this relationship. There is a negative association between income-to-AMI ratios and the number of occupants per bedroom. Across all income groups, those living in supply-constrained markets live, on average, in more crowded units that those less constrained MSAs.

However, when I estimate the relationship between the ratio of unit occupants to bedrooms while controlling for the full set of demographic occupant characteristics, only in my naïve model is the coefficient on the constrained dummy variable positive and statistically significant. With this outcome variable, however, using the full set of demographic controls may lead me to over-specify my regression. In the models presented in Columns 1 and 2 of **Table 14**, I include several measures of household composition as controls (a dummy for whether there are three or more adults in the unit, any children, or whether the occupant is a single parent) while also directly measuring household size in the dependent variable.

***Figure 14**: Bin-Scatter, Crowding*



When I rerun these models without the three household size controls, the coefficient on the main effect of the constrained dummy more than doubles in size and is now statistically significant. The coefficient on the interaction of the constrained dummy with the income-to-AMI ratio remains insignificant, however. This suggests that while there is a statistically significant association between living in an expensive, supply-constrained MSA and unit crowding, the relationship between crowding and income does not vary based on market characteristics.

Table 14: *Regressions, Crowding*

	(1)	(2)	(3)	(4)
	Occupants Per bedroom			
Model Type:	*OLS*	*OLS*	*OLS*	*OLS*
Treatment MSA?	**0.039****	0.012	**0.062*****	**0.042***
	(0.015)	(0.016)	(0.017)	(0.018)
Income-To-AMI Ratio	**-0.026*****	**-0.026*****	**-0.013*****	**-0.012*****
	(0.002)	(0.001)	(0.002)	(0.002)
Treatment X Income-To-AMI Ratio	--	0.001	--	-0.005
		(0.004)		(0.004)
Located in Central City?	**0.083*****	**0.040*****	**0.033*****	-0.010
	(0.005)	(0.005)	(0.006)	(0.006)
Treatment X Located in Central City?	--	**0.137*****	--	**0.138*****
		(0.013)		(0.015)
3 or More Adults in Unit?	**0.193*****	**0.193*****	--	--
	(0.008)	(0.008)		
Any Children?	**0.548*****	**0.548*****	--	--
	(0.008)	(0.008)		
Single Parent?	**-0.191*****	**-0.192*****	--	--
	(0.010)	(0.010)		
HH Head Age	**-0.005*****	**-0.005*****	**-0.008*****	**-0.008*****
	(0.000)	(0.000)	(0.000)	(0.000)
HS Grad?	0.006	0.006	0.008	0.007
	(0.006)	(0.006)	(0.007)	(0.007)
College Grad?	**-0.072*****	**-0.072*****	**-0.107*****	**-0.107*****
	(0.005)	(0.005)	(0.006)	(0.006)
HH Head Black?	**-0.035*****	**-0.031*****	0.014	**0.018***
	(0.006)	(0.006)	(0.007)	(0.007)
HH Head Asian?	**0.080*****	**0.080*****	**0.180*****	**0.180*****
	(0.012)	(0.012)	(0.014)	(0.014)
HH Head Latinx?	**0.180*****	**0.182*****	**0.306*****	**0.307*****
	(0.008)	(0.008)	(0.009)	(0.009)
Renter?	**0.346*****	**0.343*****	**0.237*****	**0.234*****
	(0.006)	(0.006)	(0.006)	(0.006)
Subsidized Rent?	**-0.095*****	**-0.099*****	**-0.081*****	**-0.086*****
	(0.013)	(0.013)	(0.014)	(0.014)
Constant	**0.829*****	**0.837*****	**1.263*****	**1.268*****
	(0.015)	(0.015)	(0.017)	(0.017)
MSA Fixed Effects?	**Yes**	**Yes**	**Yes**	**Yes**
N	114,584	114,584	114,584	114,584
adj. R-sq	0.42	0.42	0.23	0.23

Standard errors in parentheses; * p<.05, ** p<.01, *** p<.001

Note: Data from the 2011 and 2013 metro-samples of the American Housing Survey. All the regressions are weighted using the suvery weights provided in the AHS. Excluding the weights has little impact on the regressions.

Figure 15 shows the linear prediction of occupants per bedroom based on whether the observation is in an expensive, supply-constrained MSA or not. My models suggest that the average observation in a constrained MSA lives in a house with slightly under 1.1 occupants-per-bedroom, while the average unit in an unconstrained MSA has under 1 person-per-bedroom.

Figure 16 shows the estimated central city and suburban marginal effects of location in a constrained MSA on the ratio of bedrooms to household size. As the plot shows, the marginal effect of living in a constrained MSA is much larger for central city residents than it is for those in the suburbs. My models suggest that living in the central city of a constrained MSA increases the predicted ratio of occupants to bedrooms by .17, while the marginal effect on suburban residents is only .04.

Figure 15: *Linear Prediction, Crowding*

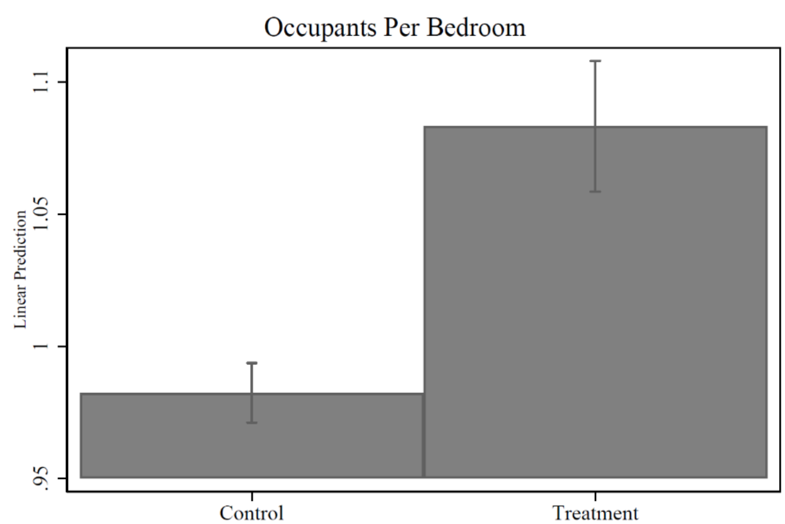
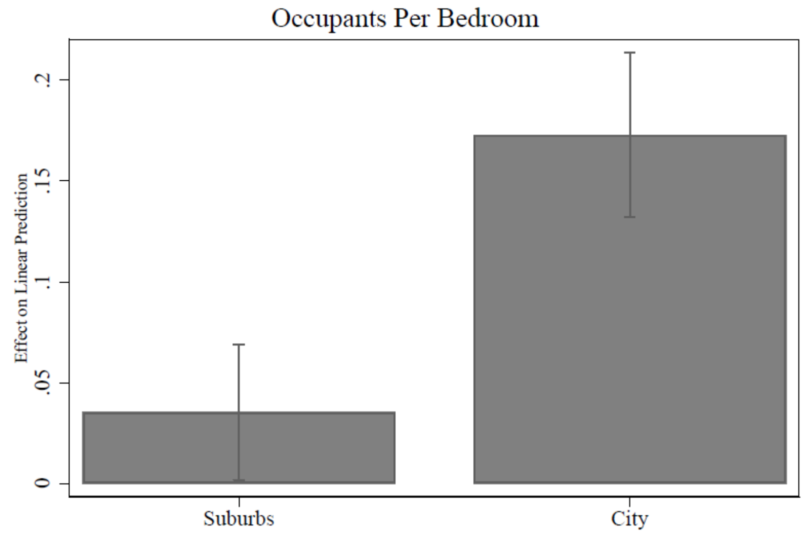


***Figure 16*:** City v. Suburbs, Crowding



Based on this analysis alone, it is difficult to know whether the crowding I observe in constrained MSA is grounds for concern. While people in supply-constrained MSAs live in smaller units relative to their household size, it may well be that they are not living in too-small units, but rather that people in unconstrained markets consume too much housing. Scholars have argued that sprawling patterns of development, fueled in no small measure by federal government policies like the mortgage interest tax deduction, encourage people to occupy large, energy inefficient houses (Dietz & Haurin, 2003). Thus, an unintended, but ultimately socially positive, consequence of supply constraints may be the way in which the cut against other policies which unwisely incentivize over-consumption.

While this may be true on net, there is a small but growing literature which finds that low-income people respond to high housing prices by doubling-up with friends or family members or by crowding into small units (Clark, Deurloo, & Dieleman, 2000; Díaz McConnell, 2016; Evans, Lepore, & Allen, 2000). And in a related literature, scholars find crowding can harm individual mental health and other life outcomes, especially among children (Evans, Lercher, & Kofler, 2002; Newman, 2008). These findings do not settle this debate but suggest the need for more research to understand whether supply constraints lead to over-crowding among low-income households and thereby contribute to the related problems such housing arrangements cause.

Discussion and Conclusions

We often falsely describe the health of housing markets, and the experiences of people living in these places, as binaries. Housing markets are either affordable or unaffordable; the housing stock is either in good or bad physical condition. But neither market conditions nor individual responses to these market conditions are so cut and dry. In cities where housing is unaffordable, not all people below some income pack up and leave town. Some may and others who would have preferred to move to the city will decide to look for housing elsewhere. But others will find ways to adjust, altering the type of housing they consume. In this project, I am interested in the experiences of those who adapt. By comparing the characteristics of housing that people occupy between expensive, supply-constrained housing markets, with those who live in relatively affordable, unconstrained places, I help improve our understanding of the dynamic ways in which supply constraints affect housing markets and the experiences of people living in these places.

My design has several drawbacks, however. The first is that due to data limitations, I am only able to measure supply constraints at the MSA-level. But supply constraints are not uniform across markets—within a given housing market constraints that affect the development of new housing often vary dramatically from municipality to municipality and from neighborhood to neighborhood. Housing prices also vary, sometimes quite starkly, within MSAs, just as they vary between them. We should thus expect housing consumption to differ based on sub-market characteristics. For a middle-income household to afford housing in Manhattan, for example, they will likely need to occupy a smaller unit and one lacking certain amenities than if they lived father out in the Bronx. And similar dynamics likely affect housing choices within relatively unconstrained housing markets. Even though at the MSA-level housing may be relatively plentiful and affordable, within these places it is possible, and perhaps likely, that the same kind of distortions I observe between MSAs occur within them. Whether and to what extent supply constraints at the neighborhood and municipality levels affect housing attributes is a worthy topic for future research.

The second limitation to my design is that even though I am careful in selecting (and testing my selection of) my constrained and unconstrained groups, it is nevertheless possible there is some factor other than supply constraints common to the constrained cities that is causing my observed outcome. One challenge with this type of analysis is that MSAs where supply constraints are the most binding tend also to be older, more built-out cities. But supply constraints in older cities will only make their preexisting differences in housing stock age worse. The only way to increase the age of a MSA's housing stock is to remove old buildings from the market or build new housing. In supply-constrained places, by definition, developers build less housing, and because they are places where people want to live, people are may be more willing to make due with old, outdated housing units. Thus, it is possible that the differences in housing consumption that I attribute to supply constraints may be due to other underlying market characteristics common to the constrained cities. But even if this is the case, supply constraints may still magnify these differences.

These limitations aside, my project is one of the first empirical efforts to measure how supply constraints and high housing prices affect the characteristics of housing people occupy. I find that people in supply-constrained housing markets tend to occupy older housing, are less likely to occupy units with amenities such as central air-conditioning and in-unit laundries and are slightly more likely to live in units with certain physical deficiencies. I also find evidence that in supply-constrained housing markets, people tend to live in smaller units relative to the size of their household. Although I do not measure directly housing costs in this project, combining these results with previous scholars who have find that in expensive, supply-constrained markets people are more likely to face housing costs burdens, not only do people in supply-constrained housing markets pay more for housing, they receive less housing in return (Charette et al., 2015).

My results suggest, however, that not all households share evenly in the benefit of living in a relatively affordable and unconstraintÂed MSA. In nearly all my models, I find that the impact of supply constraints has on housing consumption varies by income level—with differences increasing along with household income. For example, my models suggest that there is little difference in the probability that a household earning less than the AMI occupies either a physically inadequate unit or a unit without any major external problems. This finding is significant for two reasons. First, this result complicates that claim that building more housing alone will benefit the housing choices of lower-income households. My results suggest that lower-income households see little benefit in terms of improved housing quality in relatively affordable housing markets. Of course, this result may be due to variation within MSAs that I am unable to control for in this analysis. For example, the housing choices available to low-income households may be determined more by patterns of racial and economic segregation common to all MSAs in the country than by relative levels of affordability and supply constraints that vary between them. But from a policy perspective, my findings suggest that to materially improve the living conditions of lower-income households, we must do more than just break down barriers to new development at the MSA-level.

Second, my results suggest that even though higher-income households benefit more from living in affordable, unconstrainted MSAs, I find little evidence that they are aware of these benefits (or harms). This is notable as it is often these households who are effective in opposing new development (Schively, 2007). Among households with incomes above the AMI, my models suggest that there is little difference between my constrained and unconstrained MSAs in the likelihood that a household either rates their unit in poor physical condition or responds that their landlord to maintenance requests. We need more research to understand what drives subjective assessments of unit quality. But my findings suggest that for planners seeking to break-down local opposition to new development, communicating to higher income households on how supply constraints affect their own housing consumption may be an effective strategy.

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CHAPTER 5

Conclusion

In this dissertation, I have presented three essays examining different issues related to housing quality. In the first, I analyze the spatial distribution of poor-quality housing units in a declining city and test whether the presence of houses with external quality problems affect neighborhood housing values. In the second, I examine whether housing quality problems are more common in housing markets that strictly regulate new residential development. In the final essay, I examine how housing consumption differs for people who live in superlatively expensive markets which under-build new housing.

As these essays have illustrated, there are several reasons why the quality of housing is an important topic for practicing planners, policy makers, and academics interested in housing issues. First, housing quality is important for the health, safety, and stability of neighborhoods. As I show in my first essay, poor-quality housing may serve as a disamenity which impacts the satisfaction of current residents and the overall desirability of a neighborhood. A dilapidated house may be unsafe, attract crime, be aesthetically displeasing, or signal a decay of neighborhood order. And by making neighborhoods less desirable places, poor-quality housing may lower housing values, discourage owners from maintaining their properties, and, ultimately, contribute to further decline in the quality of a neighborhood's housing stock.

Additionally, while I only discuss the topic in passing in this project, housing quality not only impacts neighborhood outcomes, it also affects the outcomes of people who occupy these units. Researchers have found that living in poor-quality housing has a negative impact on individual economic outcomes, physical and mental health, and childhood development (Evans, Wells, Chan, & Saltzman, 2000; S. Newman & Holupka, 2018; S. J. Newman & Garboden, 2013; Read, 1991). While urban scholars have long stressed the importance of neighborhood effects—the impact that neighborhood conditions have on life outcomes—it is only recently that we have begun to acknowledge the importance of, as Newman (2008) describes, housing effects.

In their work, planners and other professionals involved in urban policy must balance the sometimes-conflicting goals of improving the lives of individuals and improving the safety, health, and stability of places. In many aspects of urban policy, this place- versus people-based conflict is difficult to overcome. Addressing problems of housing quality, however, can improve the stability of neighborhoods and the life-outcomes of people. In this way, housing quality is a rare policy arena which aligns the dual obligations planners hold to people and to place.

But poor-quality housing is not just a problem confronting planners in declining cities, it is also a consequence of a wider set of planning policies that affect the economic health of cities and the functioning of housing markets. We should thus not only consider housing quality as a problem to fix, but also as an outcome to consider when designing urban policy.

In my third essay, I show how, in addition to driving up prices, underbuilding housing can affect the quality of housing people occupy. In cities where housing is expensive, we know that there are many ways people alter their housing consumption in response. Some spend less on other goods, or put less away into savings, some move to harder-to-access or under-served neighborhoods, while others crowd into small units (Díaz McConnell, 2017; A. C. Goodman, 2003; S. J. Newman, 2008).

We tend only to consider quality in supply-constrained markets in the context of the upgrading of the existing housing stock. From this perspective, higher-income households remodeling existing units is less of a problem, *per se*, than it is an indicator of neighborhood change and gentrification (Helms, 2003). And, especially in my third essay, I find some evidence of this trend. One of the clearest differences I identify between people living in highly-constrained and relatively unconstrained places is in the age of housing people occupy. Compared to similar people living in markets with elastic housing supplies, at all income levels, people in constrained cities live in older housing.

But even though upgrading existing, formerly low-quality housing is a highly visible phenomena that occurs in supply-constrained markets, it may not be representative of the housing experiences of most people living in these places. For example, in my third essay, I find that across all income levels, people living in markets that under-build new housing are substantially less likely to occupy units with certain modern amenities like central air-conditioning or in-unit laundry facilities.

And in my final essay, I find evidence that people respond to high housing prices by living in older houses, those lacking certain amenities, and by crowding into relatively small units than they would in places where supply more closely matched demand. Although my results are preliminary, they do add nuance to our understanding of the ways in which underbuilding affect the housing consumption of people living in these places.

There are two main reasons why developing such a nuanced view is important. First, in places where supply constraints are the most binding, planners and policy makers need to understand the many ways in which high housing costs affect the communities they serve. Today in many expensive cities, there is growing, although still largely grassroots, support for programs to alleviate residents' mounting housing cost burdens—such as rent controls and inclusionary zoning. While we should give such programs serious consideration, my results suggest that cost burdens are not the only housing problems that exist in these cities. Easing cost burdens is important, but so too is improving the quality of housing people consume.

Second, if we are to address the underlying problems cause cities and regions to undersupply housing, it will help to know the full extent of the impact these constraints have on housing markets. Creating the necessary political coalitions to support expansive new development is challenging. Educating planners, politicians, and residents of the ways in which underbuilding affects the quality of the housing stock may help push us closer to the support necessary for widespread and lasting policy change.

While the work I present here is useful, two distinct, but ultimately related factors limited what questions I was able to ask in these projects—the availability of data and a lack of understanding of what aspects of housing quality matter. At the national level, the AHS is the only data source available to scholars and policy makers interested in issues related to housing quality. And to be certain, the breadth of the questions asked in the AHS, its panel design, and its consistency over time make it a useful tool for certain questions. But as previous scholars have argued, in part because of the challenges inherent in measuring housing quality and in part because of the age of its design, the AHS is not particularly useful for those interested in questions of housing quality (Newman & Garboden, 2013).

Further, the Census bureau and HUD designed the AHS to answer questions about the health of the national and, in the case of the metropolitan waves, regional housing stocks. But, as I discuss in more detail in my third essay, housing quality can vary dramatically within regional housing markets, just as it can between them. While there is still much we can learn by comparing housing consumption across markets, there are equally, if not more, interesting questions we can answer if we had better data available on housing quality within regional housing markets.

Of course, some of these data do exist—such as the property conditions inventory from Cleveland I used in my first essay. Surveys such as this are incredibly useful in exploring the causes and consequences of housing quality problems at the neighborhood level. But, because of these high cost of these surveys, they often only measure relatively easy-to-observe housing characteristics—like external housing problems—and are rarely repeated, thus making it difficult to study causality or long-term trends. Developing and maintaining better data will improve understanding of, and thus ability to respond to, issues of housing quality.

The second challenge facing analysts interested in the physical quality of housing in the US is less a matter of measurement than it is of definition. Or course, this problem is related to that of data-availability—our understanding of what aspects of housing quality matter are underdeveloped, in part, because we lack the appropriate data to study this question; but we lack the appropriate data, in part, because we lack a consensus on what aspects of housing quality matter.

This is not to say that scholars do not think about these about these questions. As I have explained throughout this project, there are scholars and analysts in a diverse range of fields, including public health, planning, design, economics, and sociology, that study issues either directly or tangentially related to the importance of housing quality for people, neighborhoods, and cities. However, few scholars have attempted to bridge the findings of these disparate fields. It is thus a worthy and useful project, and on that is critical if we are to improve our measurement of housing quality, to synthesize the findings of scholars who already study these issues.

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APPENDIX

Appendix 1*: Grading Criteria*

Source: Thriving Communities Institute

Appendix 2: *MSA Sample by Year*

	2002	2003	2004	2007	2009	2011	2013
Atlanta	--	--	5,132	--	--	3,578	--
Baltimore	--	--	--	2,733	--	--	4,065
Birmingham	--	--	--	--	--	4,387	--
Boston	--	--	--	2,771	--	--	4,025
Buffalo	4,555	--	--	--	--	2,817	--
Charlotte	5,119	--	--	--	--	4,101	--
Chicago	--	2,863	--	--	--	--	--
Cincinnati	--	--	--	--	--	4,132	--
Cleveland	--	--	4,722	--	--	4,129	--
Columbus	4,936	--	--	--	--	4,157	--
Dallas	5,743	--	--	--	--	2,938	--
Denver	--	--	4,834	--	--	3,777	--
Detroit	--	2,186	--	--	--	--	--
Fort Worth	5,052	--	--	--	--	3,194	--
Hartford	--	--	4,728	--	--	--	4,440
Houston	--	--	--	2,861	--	--	7,798
Indianapolis	--	--	4,814	--	--	4,144	--
Jacksonville	--	--	--	--	--	--	4,223
Kansas City	4,830	--	--	--	--	3,978	--
Las Vegas	--	--	--	--	--	--	4,121
Los Angeles	--	3,717	--	--	--	--	--
Louisville	--	--	--	--	--	--	4,197
Memphis	--	--	4,644	--	--	4,233	--
Miami	4,770	--	--	2,647	--	--	3,558
Milwaukee	4,823	--	--	--	--	2,878	--
Minneapolis	--	--	--	2,847	--	--	3,990

	2002	2003	2004	2007	2009	2011	2013
Nashville	--	--	--	--	--	--	4,166
New Orleans	--	--	4,516	--	4,888	4,545	--
New York	--	2,103	--	--	--	--	--
Newark	--	--	--	--	--	--	--
Oakland	--	--	--	--	--	3,994	--
Oklahoma City	--	--	4,829	--	--	--	5,061
Orlando	--	--	--	--	--	--	4,129
Pheonix	5,056	--	--	--	--	2,540	--
Philadelphia	--	2,353	--	--	--	--	--
Pittsburgh	--	--	4,723	--	--	3,955	--
Portland	4,917	--	--	--	--	4,019	--
Providence	--	--	--	--	--	4,368	--
Richmond	--	--	--	--	--	--	4,242
Rochester	--	--	--	--	--	--	4,726
Sacramento	--	--	4,728	--	--	4,118	--
Salt Lake City	--	--	--	--	--	--	--
San Antonio	--	--	4,863	--	--	--	5,056
San Bernardio	--	--	--	--	--	2,483	--
San Diego	4,872	--	--	--	--	2,457	--
San Francisco	--	--	--	--	--	4,085	--
San Jose	--	--	--	--	--	4,153	--
Seattle	--	--	4,731	--	6,201	--	3,939
St. Louis	--	--	4,741	--	--	3,917	--
Tampa	--	--	--	3,053	--	--	3,814
Tempe	--	--	--	--	--	--	4,313
Washington DC	--	--	--	2,781	--	--	3,567

Appendix 3*: Full Hedonic Results*

	Dependent Variable: LN(Sales Value)							
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
# D/F wn 250' (Radius)	**-0.038***** (0.007)	--	-0.002 (0.007)	--	--	--	--	--
# D/F btwn 250' & 500' (Radius)	-0.004 (0.004)	--	-0.007 (0.004)	--	--	--	--	--
# D/F btwn 500' & 1,000' (Radius)	**-0.006***** (0.002)	--	**-0.005***** (0.002)	--	--	--	--	--
# D/F wn 250' (Synthetic Block)	--	**-0.044***** (0.013)	--	0.022 (0.013)	--	--	--	--
# D/F btwn 250' & 500' (SB)	--	-0.019 (0.011)	--	-0.015 (0.010)	--	--	--	--
# D/F btwn 500' & 1,000' (SB)	--	-0.003 (0.008)	--	-0.004 (0.008)	--	--	--	--
# C/D/F wn 250' (Radius)	--	--	--	--	0.004 (0.003)	--	--	--
# C/D/F btwn 250' & 500' (Radius)	--	--	--	--	-0.002 (0.001)	--	--	--
# C/D/F btwn 500' & 1,000' (Radius)	--	--	--	--	**-0.002***** (0.001)	--	--	--
# C/D/F wn 250' (SB)	--	--	--	--	--	0.002 (0.004)	--	--
# C/D/F btwn 250' & 500' (SB)	--	--	--	--	--	-0.002 (0.004)	--	--
# C/D/F btwn 500' & 1,000' (SB)	--	--	--	--	--	-0.003 (0.003)	--	--
Any C/D/F wn 250' (SB)?	--	--	--	--	--	--	**-0.104***** (0.023)	--
Any C/D/F btwn 250' & 500' (SB)?	--	--	--	--	--	--	-0.009 (0.023)	--
Any C/D/F btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	-0.037 (0.022)	--
Any C wn 250' (SB)?	--	--	--	--	--	--	--	**-0.103***** (0.022)
Any C btwn 250' & 500' (SB)?	--	--	--	--	--	--	--	-0.014 (0.002)
Any C btwn 500' & 1,000' (SB)?	--	--	--	--	--	--	--	-0.031 (0.022)

Continued.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
# Vacant Parcels wn 250'	**-0.034*****	**-0.035*****	**-0.026*****	**-0.026*****	**-0.027*****	**-0.026*****	**-0.026*****	**-0.027*****
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
# Vacant Parcels btwn 250' & 500'	-0.001	-0.003	-0.002	-0.003	-0.002	-0.004	-0.002	-0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
# Vacant Parcels btwn 500' & 1,000'	**-0.009***	**-0.010****	**-0.008***	**-0.009****	**-0.008***	**-0.009***	**-0.008***	**-0.008***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Rental Unit?	**-0.078*****	**-0.080*****	**-0.108*****	**-0.109*****	**-0.108*****	**-0.110*****	**-0.107*****	**-0.107*****
	(0.022)	(0.022)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
Unit Area (000s)	**0.278*****	**0.283*****	**0.289*****	**0.291*****	**0.288*****	**0.291*****	**0.289*****	**0.000*****
	(0.029)	(0.029)	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)	0.000
Total Lot Area (000s)	**0.020*****	**0.021*****	**0.019*****	**0.021*****	**0.019*****	**0.020*****	**0.019*****	**0.000*****
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	0.000
# of Bathrooms	**0.138*****	**0.136*****	**0.135*****	**0.134*****	**0.135*****	**0.133*****	**0.131*****	**0.131*****
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)
# of Bedrooms	**-0.028***	**-0.026***	**-0.028***	**-0.027***	**-0.027***	**-0.027***	**-0.028***	**-0.028***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Hip Roof?	0.017	0.012	0.011	0.01	0.005	0.009	0.011	0.012
	(0.075)	(0.075)	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)	(0.073)
Gabel Roof?	-0.011	-0.017	-0.019	-0.021	-0.024	-0.022	-0.018	-0.018
	(0.065)	(0.065)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)	(0.064)
Slate Roof?	-0.031	-0.023	-0.036	-0.035	-0.029	-0.036	-0.034	-0.034
	(0.076)	(0.076)	(0.075)	(0.075)	(0.075)	(0.075)	(0.075)	(0.075)
Shingle Roof?	0.039	0.046	0.014	0.013	0.021	0.013	0.016	0.015
	(0.072)	(0.072)	(0.070)	(0.070)	(0.070)	(0.070)	(0.070)	(0.070)
Unit Age?	**-0.008*****	**-0.008*****	**-0.007*****	**-0.007*****	**-0.007*****	**-0.007*****	**-0.007*****	**-0.007*****
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
One unit in Structure?	**0.330*****	**0.335*****	**0.272*****	**0.276*****	**0.272*****	**0.275*****	**0.270*****	**0.270*****
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)
Ranch-style?	**-0.139****	**-0.140****	**-0.150*****	**-0.152*****	**-0.152*****	**-0.152*****	**-0.149****	**-0.149****
	(0.046)	(0.046)	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)	(0.045)

Continued.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**
Colonial-style?	-0.015	-0.02	-0.036	-0.039	-0.031	-0.037	-0.027	-0.027
	(0.039)	(0.039)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Cape Cod-style?	-0.062	-0.066	**-0.083***	**-0.085***	**-0.083***	**-0.084***	**-0.079***	**-0.079***
	(0.039)	(0.039)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)	(0.038)
Sold Sept. to Dec?	**0.045***	**0.045***	0.038	0.039	0.038	0.038	0.037	0.038
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Sold May to Aug?	**0.069*****	**0.069*****	**0.062*****	**0.063*****	**0.062****	**0.063*****	**0.062*****	**0.062*****
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
Sold Jan to Arpil?	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Unit has garage?	**0.178*****	**0.178*****	**0.163*****	**0.163*****	**0.165*****	**0.163*****	**0.164*****	**0.164*****
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Unit has central AC?	**0.187*****	**0.189*****	**0.176*****	**0.178*****	**0.175*****	**0.178*****	**0.172*****	**0.172*****
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
Unit has brick exterior?	**0.075***	**0.079****	**0.083****	**0.085****	**0.083****	**0.085****	**0.080****	**0.080****
	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)	(0.029)
C-rated in TCI Survey?	--	--	**-0.367*****	**-0.371*****	**-0.370*****	**-0.371*****	**-0.346*****	**-0.345*****
			(0.023)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)
D-rated in TCI Survey?	--	--	**-0.710*****	**-0.734*****	**-0.723*****	**-0.722*****	**-0.700*****	**-0.702*****
			(0.045)	(0.045)	(0.044)	(0.044)	(0.044)	(0.044)
F-rated in TCI Survey?	--	--	**-1.265*****	**-1.280*****	**-1.276*****	**-1.276*****	**-1.258*****	**-1.258*****
			(0.068)	(0.068)	(0.068)	(0.068)	(0.068)	(0.068)
N	17352	17352	17352	17352	17352	17352	17352	17352
R-sq	0.393	0.392	0.416	0.415	0.416	0.415	0.416	0.416
ll	-25393.08	-25414.238	-25065.182	-25073.6	-25060.664	-25074.936	-25058.834	-25059.366
aic	51200.161	51242.475	50552.364	50569.2	50543.328	50571.871	50539.669	50538.732
bic	52806.784	52849.098	52190.033	52206.869	52180.997	52209.54	52177.337	52168.639

Appendix 4: *Full Regressions, Property Quality*

	Model 1	Model 2	Model 3	Model 4	Model 5
	D or F?	***C, D, or F***	***C?***	***D?***	***F?***
# D/F wn 250' (Synthetic Block)	**0.569***** (0.014)	--	--	--	--
# D/F btwn 250' & 500' (SB)	0.022 (0.013)	--	--	--	--
# D/F btwn 500' & 1,000' (SB)	0.012 (0.010)	--	--	--	--
# C/D/F wn 250' (SB)	--	**0.277***** (0.004)	--	--	--
# C/D/F btwn 250' & 500' (SB)	--	**-0.049***** (0.004)	--	--	--
# C/D/F btwn 500' & 1,000' (SB)	--	0.001 (0.002)	--	--	--
# C wn 250' (SB)	--	--	**0.303***** (0.004)	**0.023**** (0.008)	0.022 (0.013)
# C btwn 250' & 500' (SB)	--	--	**-0.029***** (0.004)	**-0.053***** (0.008)	**-0.080***** (0.014)
# C btwn 500' & 1,000' (SB)	--	--	**0.012***** (0.003)	**-0.018**** (0.006)	-0.005 (0.011)
# D wn 250' (SB)	--	--	**-0.157***** (0.014)	**0.683***** (0.017)	-0.033 (0.032)
# D btwn 250' & 500' (SB)	--	--	**-0.075***** (0.012)	**0.068***** (0.018)	-0.042 (0.030)
# D btwn 500' & 1,000' (SB)	--	--	**-0.026**** (0.010)	**0.041**** (0.015)	-0.033 (0.024)
# F wn 250' (SB)	--	--	**-0.194***** (0.028)	-0.017 (0.037)	**0.963***** (0.034)
# F btwn 250' & 500' (SB)	--	--	**-0.084***** (0.023)	-0.017 (0.033)	**0.234***** (0.038)
# F btwn 500' & 1,000' (SB)	--	--	**-0.035*** (0.016)	-0.027 (0.024)	**0.179***** (0.030)
# Vacant Parcels wn 250'	**0.080***** (0.010)	**0.074***** (0.007)	**0.049***** (0.007)	**0.065***** (0.012)	**0.079***** (0.017)
# Vacant Parcels btwn 250' & 500'	**0.017*** (0.007)	0 (0.005)	-0.004 (0.005)	**0.019*** (0.008)	0.013 (0.012)
# Vacant Parcels btwn 500' & 1,000'	0.002 (0.005)	**0.008*** (0.003)	**0.009*** (0.004)	**0.012*** (0.006)	-0.001 (0.009)

Continued.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	D or F?	***C, D, or F***	***C?***	***D?***	***F?***
Unit under 20 years old?	**-2.620*****	**-3.077*****	**-2.938*****	**-2.426*****	**-3.151*****
	(0.287)	(0.161)	(0.191)	(0.312)	(0.722)
Unit Between 20 and 50 years old?	**-0.838*****	**-1.188*****	**-1.159*****	**-0.752****	**-1.104***
	(0.208)	(0.110)	(0.125)	(0.232)	(0.443)
Unit between 50 and 70 years old?	**-0.734*****	**-0.572*****	**-0.518*****	**-0.699*****	**-0.824*****
	(0.107)	(0.045)	(0.047)	(0.120)	(0.227)
Unit over 70 years old?	--	--	--	--	--
Unit area (000s of SF)	**-0.125***	-0.057	-0.028	**-0.164****	0.045
	(0.052)	(0.030)	(0.032)	(0.060)	(0.093)
Lot area (000s of SF)	0.011	**0.013*****	**0.011****	**0.015***	-0.016
	(0.007)	(0.004)	(0.004)	(0.007)	(0.021)
# of Bathrooms?	0.027	-0.001	-0.015	0.01	0.042
	(0.046)	(0.027)	(0.029)	(0.053)	(0.083)
# of Bedrooms?	**0.047***	0.024	0.01	**0.049***	0.04
	(0.021)	(0.012)	(0.013)	(0.024)	(0.037)
Listed in Rental Registry?	**-0.667*****	**-0.177*****	-0.014	**-0.596*****	**-0.719*****
	(0.064)	(0.029)	(0.030)	(0.072)	(0.124)
Hip Roof?	**-0.375***	**-0.215****	-0.131	-0.237	**-0.603***
	(0.148)	(0.082)	(0.088)	(0.171)	(0.266)
Gabel Roof?	**-0.288***	**-0.144***	-0.079	-0.202	**-0.420***
	(0.122)	(0.071)	(0.076)	(0.142)	(0.209)
Slate Roof?	**-0.286***	-0.099	-0.025	-0.142	-0.307
	(0.136)	(0.080)	(0.087)	(0.161)	(0.229)
Shingle Roof?	**-0.354****	**-0.180***	-0.089	-0.211	-0.347
	(0.131)	(0.077)	(0.084)	(0.155)	(0.219)
One unit in Structure?	**-0.530*****	**-0.498*****	**-0.371*****	**-0.491*****	**-0.498*****
	(0.056)	(0.032)	(0.034)	(0.064)	(0.100)
Ranch-style?	0.051	0.09	0.095	-0.036	0.274
	(0.130)	(0.062)	(0.066)	(0.148)	(0.254)
Colonial-style?	-0.114	-0.086	-0.064	-0.078	-0.161
	(0.094)	(0.049)	(0.052)	(0.108)	(0.181)

Continued.

	Model 1	Model 2	Model 3	Model 4	Model 5
	D or F?	***C, D, or F***	***C?***	***D?***	***F?***
Cape Cod-style?	-0.121	**-0.114***	-0.092	-0.096	-0.174
	(0.095)	(0.049)	(0.052)	(0.109)	(0.184)
Unit has garage?	**-0.366*****	**-0.360*****	**-0.273*****	**-0.308*****	**-0.420*****
	(0.033)	(0.019)	(0.020)	(0.038)	(0.061)
Unit has central AC?	**-0.980*****	**-0.655*****	**-0.557*****	**-0.878*****	**-1.201*****
	(0.122)	(0.045)	(0.047)	(0.133)	(0.278)
Unit has brick exterior?	-0.103	**-0.116****	**-0.106***	-0.124	-0.104
	(0.078)	(0.039)	(0.041)	(0.090)	(0.147)
N	99,361	109,937	109,931	99,196	74,244
ll	-15513.555	-42215.926	-38537.196	-12616.68	-5406.51
aic	31393.11	84827.852	77480.392	25609.36	11131.03
bic	33132.802	86730.169	79430.736	27396.272	12596.23

Appendix 5: Maintenance Regressions by Building Size

	(1) Landlord Responds to Minor or Major Requests Quickly?	(2) Landlord Responds to Minor or Major Requests Quickly?
Sample	**Small Buildings**	**Large Buildings**
Model Type:	*Logit*	*Logit*
Treatment MSA?	0.358	**0.542****
	(0.193)	(0.208)
Income-To-AMI Ratio	**0.108****	**0.127***
	(0.035)	(0.053)
Treatment * Income-To-AMI Ratio	-0.103	-0.009
	(0.063)	(0.067)
Located in Central City?	0.041	-0.074
	(0.050)	(0.060)
Treatment * Located in Central City?	0.019	-0.08
	(0.064)	(0.096)
3 or More Adults in Unit?	0.08	0.076
	(0.061)	(0.086)
Any Children?	-0.008	-0.073
	(0.070)	(0.100)
Single Parent?	**0.007*****	**0.010*****
	(0.002)	(0.002)
HH Head Age	-0.006	-0.013
	(0.054)	(0.067)
HS Grad?	0.12	0
	(0.063)	(0.067)
College Grad?	**-0.149***	-0.097
	(0.066)	(0.072)
HH Head Black?	0.019	**-0.197***
	(0.121)	(0.099)
HH Head Asian?	**-0.130***	**-0.145***
	(0.065)	(0.073)
HH Head Latinx?	**0.249****	**0.247****
	(0.093)	(0.088)
Subsidized Rent?	**0.344***	**0.613****
	(0.166)	(0.195)
Constant	**33.042*****	**0.819*****
	(0.701)	(0.080)
MSA Fixed Effects?	**Yes**	**Yes**
N	23,446	19,124

Standard errors in parentheses; * p<.05, ** p<.01, *** p<.001

Note: Data from the 2011 and 2013 metro-samples of the American Housing Survey. All the regressions are weighted using the survey weights provided in the AHS. Excluding the weights has little impact on the regressions. For landlord responsiveness regressions, I limit the sample to renter-occupied units and thus exlude the unit tenure control. Small buildings are those with fewer than 6 units; large buildings are those with 6 or more.